LOOK WITHIN

TRADE MARK

This Work is Respectfully

Inscribed

to

ANDREW CARNEGIE

Friend of Learning

A WORD BOOK

HAWKINS' ELECTRICAL DICTIONARY

"FOR ONE WORD A MAN IS OFTEN DEEMED TO BE WISE, AND FOR ONE WORD HE IS OFTEN DEEMED TO BE FOOLISH. WE OUGHT TO BE CAREFUL, INDEED, WHAT WE SAY."

HAWKINS' ELECTRICAL DICTIONARY

A
CYCLOPEDIA OF WORDS, TERMS, PHRASES AND DATA USED IN THE ELECTRIC ARTS, TRADES AND SCIENCES

BY
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AND ASSOCIATES

INCLUDING THE STANDARDIZATION RULES OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

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NOTIFICATION

Know all Men by these Presents:

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"GIVE INSTRUCTION TO A WISE MAN, AND HE WILL BE YET WISER; TEACH A JUST MAN AND HE WILL INCREASE IN LEARNING."—*Proverbs.*

AUTHOR'S FOREWORD.

Total and sudden transformations of a language seldom happen, says Samuel Johnson, author of the first practical and comprehensive dictionary defining English words.

But, he says, there are causes which, though slow in their operation and invisible in their progress, are perhaps as much superior to human resistance as the revolutions of the sky. By the cultivation of various sciences, language is amplified.

Thus, the words and terms relating to electricity have, in the course of about fifty years, come to be a part of a language which has been growing and expanding for a thousand years.

Electrical terms differ widely from words which have grown out of one's daily life and which are seen and used so often that one becomes familiar with their meaning almost without effort. The incorporation of these new electrical terms in the old, to use a scriptural phrase, is like putting new wine in old vessels, albeit the new words have been and are being coined by highly educated scientific men to express some process, result or phenomenon which has been discovered only by months or years of careful and laborious experiment in the new field. Many of these words, such as *erg* and *dyne*, for instance, are seldom seen by the general reader, hence the necessity for a work like the present one which shall explain in simple language many of these terms which are of such recent origin that the literary dictionaries treat them inadequately or do not mention them at all.

George Herbert says, step after step the ladder is ascended, and so have the definitions and meanings of electrical words made their way until now it has seemed to the author that the time has arrived when a work embracing a description of the elements and practical applications of this new industrial agent, wide in its extent and minute in its application, can be advantageously presented.

While a great part of the contents of the dictionary is written for engineers and managers of electrical properties, much of its matter will be found to be of genuine interest to the intelligent public. For instance, the meanings which grow out of the use of such words as the electric light, the motor, the telephone, the dynamo, telegraphy, electric traction, lighting and heating, electric metallurgy, the central station, etc. In the use of these words there is a wealth of theory given, as well as of practice. Every phrase given contains the germ of more or less enlarged technical discussion; as a sailor would express it, each word is the end of a rope, which pulled out to its extreme length leads to a beneficial educational end.

For more than kind co-operation in the arduous task incident to the completion of this work the author desires to name specially EDWARD F. STEVENS, B. A., formerly Head of the Technical Reference Department, Pratt Institute Library, for his co-operation and efforts from the inception of this work to its completion, involving extensive research through the entire field of electrical science, also FRANK DUNCAN GRAHAM, B. S., M. S. (Princeton University, 1899, 1902), and M. E. (Stevens Institute, 1902.) The author's thanks are extended to JOHN HARMS, M. E. (Leyden University), who pending his work on this book received an appointment as chief engineer in laying out the hydro-electric power plant at Rio Janeiro.

Credit is also due to MR. VICTOR HAWKINS for untiring industry in word selection and in the general make-up of the volume. Following in order, the author names CHARLES E. BOOTH, and R. SPRING for skillful work in the preparation and revision of author's manuscript, also to MR. HARRY HARRISON and MR. SAMUEL B. ASCHER of the L. MIDDLEDITCH PRESS.

The inclusion of a considerable number of mechanical terms requires no apology when one realizes that electrical science is only the highly specialized development of one branch of mechanical engineering.

N. HAWKINS.

A.—Abbreviation for *ampere*, the practical unit of electric current.

Abrasion of Insulation.—The wearing away of any insulating covering as the result of rubbing or chafing against a hard surface.

Abrasive.—In mechanics, an agent employed in grinding or wearing away by friction or attrition. The more common materials for this purpose are emery, powdered glass and sand.

Absolute Block System.—A system of automatic railway signaling, in which only one train at a time is permitted to enter one of the sections or blocks into which the track is divided. When the signal shows red, or danger, the train must come to a dead stop, with no part of it beyond the signal, and wait until it gets a clear signal.

Absolute Calibration.—The adjustment of an electrical measuring instrument to fixed or real values, etc. Thus, a galvanometer which does not give absolute readings may be made to do so by *calibration.*

Absolute Electrometer.—A form of electrometer which measures the voltage difference directly in the units of the centimeter-gram-second (C. G. S.) system of measurement.

Absolute Expansion.—The expansion of a liquid, regardless of the dimensions of the receptacle which contains it.

Absolute Galvanometer.—A measuring instrument, which tells the strength of an electric current by the direct application of Ohm's law; for since by this we have voltage=current×resistance, its constants being known.

Absolute Insulation.—The total insulation of an electric circuit.

Absolute Pressure.—That measured from the true zero or point of no pressure. It is equal to the pressure indicated upon the gauge, plus that of the atmosphere, which is usually taken as 14.7, or 15 lbs. Thus, 68 lbs. gauge pressure is 82.7, or 83 lbs. *absolute.*

Absolute Strength.—In mechanics, the actual breaking strength of a bar or structure, as distinguished from the safe or working load.

Absolute Temperature.—In physics, the actual temperature of anything, reckoned from *absolute zero.* It is taken as the temperature indicated by the thermometer or similar instrument, to which is added 273° Centigrade or 460° Fahrenheit, the difference between absolute zero and the zeros of the respective thermometric scales which are arbitrarily fixed.

Absolute Unit of Current.—An electric current which exerts a force of one dyne on a unit magnetic pole placed at the center of an arc of its circuit, one centimeter long and with a radius of one centimeter.

Absolute Unit of Electromotive Force.—The potential difference which exists between any two points of a conductor carrying a unit current, when *one erg of work is done per second.*

Absolute Unit of Resistance.—The resistance produced by a conductor in which unit electro-motive force causes unit current to flow.

Absolute Units.—The units of the centimeter-gram-second (C. G. S.) system of measurement.

Absolute Vacuum.—In physics, space empty or devoid of matter; the absence of pressure.

Absolute Zero.—In physics, temperature, or the heat which it represents, is regarded as a manifestation of molecular activity in any substance, the higher the temperature, the greater the motion or vibration among the molecules of which every solid, liquid or gaseous body is composed. Experiments have demonstrated that a gas expands when at the freezing point and under constant pressure about $\frac{1}{491}$ of its volume for each increase of 1° Fahr., in pressure.

Absorption Dynamometer.—An instrument for measuring power, in which the energy of a revolving wheel or shaft is absorbed by the friction of a brake. The typical form of absorption dynamometer is the *prony brake* which consists of a lever of definite length in frictional contact with a wheel or shaft and having adjustable screws by means of which the intensity of the friction may be varied. The end of the lever is attached to scales and the friction measured, from which the *brake horse-power* can be calculated.

Absorption of Gases.—In physics, the property which all liquids possess, in greater or less degree, of taking a certain quantity of gas into chemical combination with themselves. Heat is given off during this process of absorption, and should it afterwards be desired to separate the gases, an equivalent amount of heat to that given off, must be applied to the liquid.

Absorption of Light.—The retaining or absorbing by a substance, of a portion of the light rays that fall upon it; the energy of the light being retained as heat, or, sometimes, as a chemical change.

Abstract.—To withdraw; to separate; to take away; as, to separate the more volatile or soluble parts of a substance by distillation or other chemical processes.

a. c.—Abbreviation for *alternating current.*

Acceleration.—In physics, the rate at which the velocity of a body increases per unit of time. Also used to denote the rate of decrease in the velocity of a body or negative acceleration.

Accent.—In mathematics, a mark placed at the right hand of a letter, and a little above it, to distinguish magnitudes of a similar kind expressed by the same letter, but differing in value.

Accidents.—Nearly all accidents arising from contact with electric wires and electric machines it may be said are due more to the want of care than to the want of knowledge. Care and watchfulness upon the part of all who have to do with electricity cannot be too constantly observed.

Accumulation of Electricity.—1. The expending of electrical energy to produce chemical change in a storage or secondary cell for the purpose of re-developing electrical energy by a secondary chemical change in the cell.

2. The collecting of electrical energy in the plates of a Leyden jar or condenser.

Accumulator.—A term often applied to a storage battery. The storage battery now in general use has electrodes consisting of lead plates and an electrolyte consisting of dilute sulphuric acid. The combination forms a voltaic couple. In charging, the positive plates become coated with peroxide of lead and the color changes from grey to brown. The storage or secondary battery differs from the primary in that, when its energy is exhausted, it can be recharged by passing a current into it in a direction opposite to its flow when discharging.

Accumulator Distribution.—The distribution of electricity through the medium of accumulators, or *storage batteries.*

Accumulator Traction.—The electric propulsion of street railway or other cars by means of storage batteries; *storage battery traction.*

Acetate.—A salt formed by the action of acetic acid upon a base; an *acetate of lead* is much used in the arts, commonly known as *sugar of lead.*

Acetate of Copper.—A substance commonly known as *verdigris.* It is prepared by exposing copper plates to the vapor of acetic acid and the action of the air; it is much used in electroplating.

Acetimeter.—A graduated instrument for measuring the strength of acetic or other acids. Also called *acetometer.*

Acetone.—A liquid with a characteristic smell, obtained as a by-product in the distillation of wood alcohol. Acetone is used in the manufacture of chloroform, iodoform, etc. It dissolves many times its own volume of *acetylene* gas, the quantity depending upon the pressure, and is therefore used in connection with reservoirs for storing acetylene for *automobile lights.*

Acetylene Generator.—A closed vessel in which acetylene gas may be continually produced by the action of water on calcium carbide, in quantities sufficient to supply a certain number of lamps, the gas being supplied under a uniform pressure. The generators are commonly made of small size.

Achromatic.—Free from color; a term applied to a medium which transmits light, without decomposing it into its prismatic colors.

Achromatic Lens.—A lens usually made up of two separate lenses differing in shape and quality, so that each corrects and supplements the other, and light passes through the two undecomposed.

Acid.—An extremely active chemical compound formed by the union of hydrogen with an acid radical; as, for example, sulphuric acid, a compound of hydrogen, sulphur and oxygen in definite proportions.

Acid Bath.—An acid solution for cleansing the surfaces of gold, silver, copper, brass and zinc objects, preparatory to electroplating; *acid pickle.*

Acid Depolarizer.—An acid, such as nitric acid, sometimes introduced into a primary cell to prevent polarisation.

Acidimeter.—An instrument for determining the purity or strength of acids, founded on the principle that the strength of any sample of acid is proportionate to the quantity of carbonic acid gas which it disengages from a carbonate of soda or potash.

Acidulated Water.—An acid solution which is largely diluted with water; as, *a dilute solution of sulphuric acid.*

Aclinic Line.—An imaginary line on the earth's surface passing through points having no magnetic inclination or dip. Also called *magnetic equator.*

Acorns.—Light metallic acorn-shaped pieces for the ends of pendant chains connected with pull switches for lighting incandescent lamps.

Acorn Socket.—A form of incandescent lamp socket resembling an acorn in shape.

Acoumeter.—An electric instrument for measuring the acuteness of the sense of hearing. Also called *acousimeter.*

Acoustic.—Relating to, or having to do with, sound.

Acousticon.—An electrically operated instrument for the deaf. It acts to intensify low sounds and to moderate the loud ones. It consists of a receiver or transmitter, a watch case ear piece, and a battery, the three parts being connected together by a flexible cord.

Acoustics.—The science of sound; the study of the cause and phenomena of the vibrations which affect the organ of hearing; in other words, the manner in which sound is produced, and its transmission through the air.

Acoustic Synchronizer.—A sounding device for indicating the synchronous relation between two alternators by becoming silent at synchronism.

Acoustic Telegraphy.—The system of telegraphy in which the signals are read by *sound,* as distinguished from *visual telegraphy.*

Actinic.—Having the property of *actinism;* applied to the quality in the sun's rays whereby chemical changes are produced.

Actinic Photometer.—A photometer which measures the intensity of light by the chemical change produced by the light.

Actinic Ray.—A ray of light, or invisible radiant energy, which can induce chemical action. The violet and ultra violet rays of the spectrum are the most powerfully actinic.

Actinism.—That property possessed by rays of light of bringing about chemical action; as, in photography.

Actino-Electricity.—Electricity produced by the action of radiation upon crystals.

Actinograph.—1. An instrument for measuring and registering the chemical influence of rays of light.

2. An instrument for recording the variation in power of the sun's rays. Also called *actinometer.*

Active Conductor.—One through which an electric current is passing.

Active Current.—In an alternating current, a component in phase with the pressure; the working component as distinguished from the idle or wattless component; also called the energy or active component.

Active Material.—The spongy part of a storage battery plate capable of changing its nature and appearance by reason of the flow of electric current and to be endowed with a potential energy for redeveloping the electric current by a secondary chemical change.

Active Molecules.—The molecules which are broken up into their constituent *ions* during the process of electrolysis.

Active Polar Surface.—The surface of a magnet at its poles.

Active Pressure.—In an alternating current circuit, the pressure which produces a current, as distinguished from the pressure impressed upon the circuit; the *active electro-motive force.*

Active Wire.—The wire of an armature winding which produces useful electromotive force, as distinguished from *dead* or idle wire.

Activity.—In physics, the rate of doing work, or the work done in a unit of time; power.

Actual Efficiency.—The net or available energy produced by a machine divided by the total energy it absorbs. Usually called *commercial efficiency.*

Actual Energy.—Energy which is actively engaged in working, as distinguished from *potential* energy or energy in reserve; kinetic energy.

Actual Horse Power.—In steam engineering, the exact useful power given out by the engine; its amount is estimated by subtracting the power absorbed by the engine itself from the *indicated* horse power; also called *brake horse power.*

Acute.—Sharp at the end; ending in a sharp point; pointed.

Acute Angle.—An angle less than a right angle; an angle less than 90 degrees.

Acute Angle Trolley Crossing.—A trolley crossing set at the point where two trolley wires intersect at a sharp angle.

Adapter.—A form of screw coupling by means of which an incandescent lamp may be fitted to a gas fixture, or to a socket of different make.

Adherence.—The quality of clinging or sticking together of unlike particles of matter.

Adhesion.—The act or state of sticking together or being attached; the force with which distinct bodies hold together when their surfaces are brought in contact.

Adhesion, Electric.—The attraction between bodies due to unlike charges of electricity carried by them.

Adhesion, Magnetic.—The attraction between bodies due to the force of magnetic flux in them.

Adhesive Tape.—A tape prepared for insulating purposes, and designed to adhere to the substance about which it is wound.

Adiabatic.—In physics, when a gas is compressed or expanded, if the heat due to compression be not taken away or fresh heat not supplied to make up for that lost by internal work during expansion, the compression or expansion is accompanied by a change of temperature, the gas becoming hot or cold according as the gas is compressed or expanded.

Adiabatic Curve.—A curved line, as in an indicator diagram, exhibiting the variations in pressure and volume in a fluid which is expanded or compressed *adiabatically,* that is, without receiving or giving up heat. This curve differs from the hyperbolic or *isothermal* curve.

Adiathermancy.—The quality of being opaque to heat.

Adjunct.—Something joined or added to another thing, but not essentially a part of it.

Adjust.—To cause to fit; make exact; to *adjust* the parts of a machine to a standard. Also the refitting or letting together of worn machinery parts so that their original relationships shall be preserved.

Adjustable Angle Crossing.—A trolley crossing designed to admit of intersections at any required angle.

Adjustable Condenser.—A condenser in which the capacity may be changed with varying requirements.

Adjustable Resistance.—A resistance capable of being varied to a greater or less extent, as a *resistance box;* also called *variable resistance.*

Adjustable Speed Motor.—A motor, such as a shunt motor designed for a considerable range of field variation, in which the speed can be varied gradually over a considerable range, but when once adjusted remains practically unaffected by the load.

Adjustable Transmitter Arm.—In a telephone set, a cast iron arm, hinged at the base, for supporting the transmitter so that it may be adjusted to the height of the user; *a bracket arm.*

Adjuster for Lamp Pendant.—A contrivance for setting an electric lamp at any desired height or position.

Adjusting Lubricators.—Previous to starting a generator or motor, the lubricators should be examined to see that they feed the lubricant properly, and that the oil passages are not clogged. They should then be adjusted to feed an ample supply of oil on to the armature spindle. The amount required will depend upon the load and the nature of the oil used, but from 3 to 12 drops per minute of any ordinary heavy hydro-carbon oil is generally sufficient for a load varying from 6 to 30 horse power.

Adjusting Screw.—A set screw of an instrument or tool by which one part is moved upon another either for level, tension, or other purpose.

Adjustment.—The setting in order of the various parts of an apparatus or machine to insure proper working.

Admittance.—The apparent conducting power of an alternating current circuit; the reciprocal of the *impedance.*

Advanced Ignition.—Setting the spark of an internal combustion motor so that it will ignite the charge earlier. This is generally effected by turning the timing lever so that ignition occurs earlier during the compression stroke. Turning the opposite way delays the spark and consequently the ignition.

Advanced Quadrature.—In an alternating current, a phase difference of ninety degrees in advance of a succeeding phase.

Aeolotropic.—Not uniform with respect to direction.

Aeolotropism.—The quality of being not uniform with respect to direction.

Æpinus Condenser.—An apparatus. consisting essentially of two insulated brass disks with a plate of glass between them, used to illustrate by experiment the action of an electric condenser.

Æpinus, F. M. U. T.—Born 1724, died 1802. A German physicist, noted for his original investigations in electricity and magnetism. He devised magnetization by "double touch," and published an important work on electricity and magnetism (1759).

Aërial.—In wireless telegraphy, a group of conductors supported on lofty masts for the purpose of radiating into space, or receiving the electro-magnetic waves conveying the signals. Also called *antenna,* or *ærial conductor.*

Aërial Cable.—1. A cable hung overhead through the air.

2. The aërial or antenna in wireless telegraphy.

Aërial Circuit.—An electric circuit made up of overhead wires.

Aërial Conductor.—1. A conductor suspended overhead, as distinguished from one placed underground; an *overhead conductor.*

2. In wireless telegraphy, the antenna or *sky rod* for transmitting or receiving signals.

Aërial Cut-out.—A cut out inserted in an overhead wire.

Aërial Switch.—In wireless telegraphy, a switch for throwing the ærial into the circuit of the spark gap when sending impulses, and into that of the detector when receiving.

Aëriform.—Having the form or nature of air or gas. The prefix aër, in many words, signifies of or pertaining to the atmosphere or other gases.

Aëro-dynamics.—That branch of pneumatics which treats of air and other gases in motion, and their *mechanical effects.*

Aëro-ferric Inductance.—Inductance in coils having a magnetic circuit completed through both air and iron.

Aëro-ferric Magnetic Circuit.—A magnetic circuit having its course completed through both air and iron; *an open iron magnetic circuit.*

Aërometer.—An apparatus for weighing and estimating the tension of air or other gases; an instrument for ascertaining the mean bulk of air or gases in pneumatic experiments.

Aetna Material.—A trade name for an insulating compound used for strain insulators. It will withstand great heat, but is inclined to become brittle.

Affinity.—In chemistry, the property or force by which differing elements or groups of elements, when brought into contact, unite to form a new compound; chemical attraction.

After Burning.—A defect in the working of internal combustion engines. The charge does not ignite instantaneously but sluggishly, and the combustion is prolonged, causing a loss of power and imparting a series of shocks to the piston, instead of a single impulse.

After Firing.—In a gasoline engine, a succession of explosions in the mufflers caused by misfires in one or more cylinders, the unburned gas igniting by the heat of the walls or by the exhaust of the firing cylinder.

After Glow.—A form of fluorescence sometimes seen in a vacuum tube after the electric current has ceased.

Agate.—A form of free silica consisting of separate bands of quartz blended together, found principally in trap rocks and serpentine. It is regarded as a semi-precious stone, and is used, on account of its hardness, as a material for burnishers, and is engraved to form seals, etc.

Age Coating of Lamp Chamber.—The obscuring of the glass bulb or chamber of an incandescent lamp after continual use, caused by the gradual deposition of opaque matter from within.

Agglomerate Leclanché Cell.—A variety of Leclanché cell which does away with the porous inner jar, using instead a mass of manganese dioxide and carbon solidified by pressure.

Agglomeration of Carbon Grains.—The packing of the mass of granular carbon which is liable to occur in the loose carbon type of telephone transmitter, resulting in serious loss of efficiency.

Aging of Incandescent Lamp.—A gradual diminishing of the brilliancy of an incandescent lamp after continued use, due in part to the wear of the filament and in part to the age coating of the bulb.

Aging of Magnet.—Subjecting a magnet to the process of increasing its magnetic permanency.

Aging of Transformer Core.—The magnetic fatigue of a transformer core.

Agitator.—A device for stirring the solution in an electroplating bath in order to preserve a uniform density in the liquid.

Agonic Line.—An imaginary line drawn through points on the earth's surface where the magnetic needle points to the true north, or where the declination of the needle is zero.

a. h.—Abbreviation for *ampere hour.*

a. h. e.—Abbreviation for *ampere hour efficiency.*

Aiguille.—A needle; among masons, a stone boring tool; *a priming wire.*

Air.—1. The atmosphere which envelops the earth.

2. A gas consisting of a mechanical mixture of 23% of *oxygen* (by weight), 76% *nitrogen*, and 1% *argon*. Carbonic acid is present to the extent of about .03 or .04% of the volume. Obscure constituents are .01 per cent *krypton*, with small amounts of several other gases.

Air Blast for Commutator.—A stream of air directed against the surface of a dynamo commutator to prevent injurious sparking at the brushes.

Air Blast Transformer.—A transformer through which a blast of air is driven by a blower in order to reduce the temperature.

Air Break Switch.—A type of switch designed to break the circuit in the open air or in an enclosed air space, as distinguished from an oil break switch.

Air Cell.—A voltaic cell in which increased activity is produced by the absorption of oxygen from the surrounding air.

Air Churning.—The agitation of the air surrounding a rotating armature, which interferes with the efficiency of the machine.

Air Compressor.—A machine usually driven by steam, by which air is compressed in a receiver so that its expansion may be utilized as a source of power at distances.

Air Condenser.—A form of condenser in which a layer of air between the two disks serves to insulate the two charges from each other.

Air Cooled Transformer.—1. An air blast transformer.

2. A self-ventilating transformer which is cooled by the natural draught set up by the heating of the coils.

Air Cooling.—1. Reducing the temperature of a transformer or other electrical apparatus by causing air currents to pass over the heated surfaces.

2. The system of cooling an internal combustion engine cylinder by directing air against its surface.

Air Core Solenoid.—A solenoid having an air core.

Air Core Transformer.—A transformer having an air core.

Air Damping.—Arresting the oscillations of the moving parts of an electric measuring instrument by the use of a vane turning in a chamber of air.

Air Expansion Lightning Arrester.—A variety of lightning arrester in which air is caused to expand by the heat of the discharge with sufficient force to blow out the arc.

Air Field.—That part of a magnetic field in which the magnetic flux is transmitted through air alone.

Air Film of Lamp Chamber.—A film of air that clings to the inner walls of an incandescent lamp bulb despite the efforts of the air pump to exhaust it.

Air Gap.—Any open space in a circuit occupied solely by air; as, the air gap of a spark plug.

Air Gap of Commutator.—An opening or crevice left between successive segments of certain types of commutators.

Air Insulation.—Insulation in which air acts as the insulator.

Airpoise.—An instrument to measure the weight of air.

Air Pressure.—The pressure equal to 14.73 pounds on the square inch, exerted by the atmosphere upon the earth's surface at sea level; atmospheric pressure.

Air Pump.—An apparatus for pumping out the air from an enclosed space in order to produce a vacuum.

Air Resistance of Dynamo.—The resistance offered by the air to the revolutions of a dynamo.

Air Space.—The open space existing in a dynamo or motor between the polar faces of the field magnet and the surface of the armature.

Air Space Cable.—A submarine cable containing a core made up of several conductors separated from one another by a series of air spaces of cellular form.

Air Space Cut Out.—An open air space sometimes used in place of *a film cut out.*

Air Space Insulation.—Still air, that is, air without motion, is a good non-conductor of heat; therefore, an air space is frequently constructed for that purpose in covering engine cylinders or insulating refrigerators. But, as a slight difference in temperature will set up air currents between the two sides, it has been found advisable to pack the space with some extremely porous or fibrous material, such as sawdust, slagwool or charcoal, which, although permeated with air, completely checks all motion in it.

Air Thermometer.—As gases are more regular in their expansion than liquids, air is sometimes used in a thermometer bulb where small differences in temperature are to be measured with precision.

Air Vane Damping.—A frictional resistance for reducing the revolutions of an air-vane.

Air Washing of Lamp Filament.—The deteriorating action of the residue of gaseous matter in the vacuum chamber of an incandescent lamp upon the filament.

Alarm.—1. An audible warning. Alarms are of many kinds; the purpose or construction of each is usually indicated by its name. They are placed in such positions or under such circumstances as to give warning of danger or to call attention.

2. Any electrical device which automatically rings an alarm when certain disturbances occur or conditions arise at points where contacts are set.

Alarm Point.—A point in a system of fire alarm telegraphy from which a signal is sent.

Alarm Wires of Submarine Cable.—Special wires run through the fibre which separates the core of a submarine cable from the outer sheathing, so adjusted as to give an alarm when injured by an accident to the cable, in order that repairs may be made before the core itself suffers damage.

Align.—To arrange, place or form *in line;* as, to align shafting. Also spelled *aline.*

Alignment.—1. The line to which adjustment is made, or things are arranged in line.
2. The drawing of an imaginary straight line through two or more points or objects.

Alive.—A term sometimes used to describe a circuit or wire charged with electricity.

Alkali.—Chemically, a substance which yields *hydroxyl*, on being dissolved in water. The characteristics of alkalis are a caustic taste; the neutralisation of acids, forming a salt and water by the process; and turning *red* litmus paper *blue*.

Alkalimeter.—The object of this instrument is to ascertain the value of the alkalis of commerce. The strength of alkali is inferred from the amount of acid required to neutralize it.

Alkaline Bath.—A solution of caustic soda or caustic potash for removing grease from the surfaces of objects to be electroplated.

All Day Efficiency.—The average efficiency of an electrical apparatus during the 24 hours of a continuous day's operation.

Allotropy.—The power possessed by certain elements of existing in nature in more than one form. *Carbon* exists as the diamond, graphite and charcoal. *Oxygen* has an allotropic form as *ozone*, in which the atoms are condensed; *phosphorus* is also existent in two very distinct forms, the yellow and red, whose properties vary widely.

Alloy.—1. A compound of two or more metals formed by fusion, as of copper and tin, to form gun metal. When mercury is one of the constituents the resulting metal is termed an *amalgam*.

Alphabetic Telegraph.—A method of telegraphy in which the words of a despatch are spelled out, letter by letter, by an index on a dial; the A. B. C. telegraph.

Alpha (α) Rays.—One of the three types of rays emitted by radio-active substances; alpha rays are regarded as positively charged material particles.Theyare given off with great velocity, having small penetrating power, but great power to ionize a gas.

Alternating.—Undergoing successive reversals in direction. A term used to describe an electric current which periodically changes its direction; as, the *alternating current.*

Alternating Current.—A succession of electric currents which rise and fall in strength, and flow alternately in opposite directions at regular intervals. The currents or impulses vary in intensity from a plus maximum to a negative maximum, and are separated by points of zero pressure, as distinguished from a *direct*, or *continuous* current; a periodic current; abbreviated *a. c.*

Alternating Current Arc.—A voltaic arc produced by an alternating current. In an alternating current arc lamp the current forms no crater on either carbon, but uniformly tapers each one, thus causing a more horizontal dissemination of light.

Alternating Current Armature Winding.—A method of winding an armature so as to produce alternating currents.

Alternating Current Dynamo.—A generator for furnishing an alternating current. Alternating current dynamos are classified with respect to the current as: (1) Single phase, (2) two phase, or (3) polyphase; with respect to construction as, (a) those with stationary field magnet and rotating armature, (b) those with rotating field magnet and stationary armature, (c) those with both field magnet part and armature part stationary, but having revolving inductors made up of appropriate pieces of iron. Alternating current generators or *alternators* are usually multipolar, having north and south poles alternating around the field. The number of changes of direction of the current per revolution is the same as the number of coils in the armature or poles in the field, the armature coils in simple current machines being equal in number to the poles. The field magnets are often excited by a separate generator.

Alternating Current Motor.—An electric motor operated by an alternating current. Alternating current motors are of the single and polyphase types.

Alternating Current Pressure Indicator.—A voltmeter for measuring the pressure of alternating currents.

Alternating Current Rotary Transformer.—A rotary transformer for changing alternating current into direct currents, or direct currents into alternating.

Alternating Current Transformer.—a device used either to raise or lower the potential of an alternating current. It consists of an induction coil having a primary

and secondary winding and an iron core. A primary current in the primary winding induces a secondary current in the secondary of either higher or lower potential according as the number of turns in the secondary is greater or less than the number in the primary. Transformers which raise the potential of the primary current are called *step-up* transformers; those which lower it are called *step-down* transformers. The E. M. F. of the primary and secondary currents is proportional to the ratio of the number of turns in the two windings; thus, if the primary has ten turns to one of the secondary the E. M. F of the secondary will be (approximately) one-tenth that of the primary.

Alternating Current Transmission.—The use of alternating currents for the transmission of power.

Alternating Current Working.—The use of alternating currents to supply electrical energy.

Alternating Cycle.—In an alternating current, a series of current changes which are regularly repeated. The cycle begins with zero current which rises to a positive maximum, falls to zero again, thence to a negative maximum and returns to zero; the completion of the cycle is called a *period* and the number of periods accomplished in a second, the *frequency* of the alternations. The maximum value attained by the electro-motive force is the *amplitude*.

Alternating Discharge.—An electric discharge which rapidly reverses its direction; an oscillatory discharge.

Alternating Magneto-electric Machine.—A generator having *permanent* field magnets and supplying alternating currents. The armature is rotated between the poles of the magnet, and current from the commutator is taken by brushes.

Alternation.—The word from which the term alternator, etc., is derived, meaning passage from one condition to another and back again; in the alternating current cycle it is the *half period*.

Alternative Path.—A course taken by a disruptive discharge through a medium offering less resistance than the direct conducting path; a *short circuit*.

Alumina.—The chief constituent of all *clays*, and widely and abundantly diffused over the globe. It is naturally a pure white unshapen substance and the basis of *aluminum*.

Aluminum.—A metal of a silvery white color; much used for electrical conductors, etc., on account of its lightness, also in alloys with copper to form a tenacious non-corrodible bronze. It abounds in nature in the form of hydrates and silicates, the latter comprising the various clays, but is commercially prepared by the aid of electricity from cryolite and bauxite. The metal is not corroded by atmospheric influences or fresh water, also resisting nitric acid, but is decomposed by alkalis, in sea water, and by dilute sulphuric acid: it is malleable, ductile and sonorous, also a good conductor of heat and electricity.

Aluminum Bronze.—A beautiful golden colored bronze, composed of 90 parts copper to 10 of aluminum. Its tenacity largely depends upon the purity of the copper from which it is alloyed. Aluminum bronze wires are free from corrosion, hence, they are suitable for guy wires in a system of overhead construction, but the low conductivity of bronze excludes them from use as line wires.

Aluminum Wire.—An electric conductor composed of commercially (99%) pure aluminum. As compared with copper, aluminum wire has 62% conductivity and costs more than twice as much per pound, yet its weight is only 50% that of copper wire.

Alundum.—Artificial corundum made in the heat of an electric furnace; used as an *abrasive*.

Amalgam.—A combination of mercury or quicksilver with other metals.

Amalgamation of Zinc.—The application of a coating of mercury to the zinc plate of a voltaic cell, thereby forming an alloy which prevents the local action liable to arise from impurities in the zinc.

Amalgam Bond.—A form of railway track bond, employing a spiral spring containing a soft amalgam placed between the fish-plate and rail.

Amber.—A yellowish, or reddish brown translucent fossil resin, easily electrified by friction.

Ambroin.—A trade name for an insulating compound formed by mixing together fossil, copal, mica and other ingredients, and heating the mixture under pressure. Ambroin has the following characteristics claimed for it: it will resist extreme high temperatures; is not affected by moisture; can be moulded and machined, and will not shrink.

American Telegraphic Code.—The American Morse code or alphabet

American "Twist Joint."—A simple method of connecting the ends of two sections of wire by tightly twisting the ends around each other for a few turns: *the Western Union wire joint.*

American Wire Gauge.—The Brown & Sharpe wire gauge, generally used as a standard in the United States, especially for copper wire. It ranges from No. 0000, with a diameter of .46 in. to No. 36, with a diameter of .005 in.

Ammeter.—A device for measuring the number of amperes which are passing through a current and showing the same by direct reading on a scale. The ammeter is a commercial form of galvanometer in which the deflections (or twistings) of a magnetic needle are valued in amperes. Ammeters are made in various forms, based upon several different principles, among which are. (1) Permanent-magnet ammeters, (2) electro-magnet ammeters, (3) spring ammeters, (4) gravity ammeters. Many ammeters consist of moving coil milli-voltmeters connected to the terminals of shunts through which the currents to be measured are passed. The shunts are made of a high resistance alloy, and since the resistance remains constant the drop in potential between its terminals will be proportional to the currents passing through the shunts. This type is used for direct currents only. For alternating currents the electro-magnetic system is generally employed.

Ammeter Panel.—The panel of a central station switchboard upon which the principal ammeter is mounted.

Ammonia.—A colorless gas with a characteristic pungent odor (hartshorn), and a marked alkaline taste. It has a specific gravity of 8.5 (hydrogen being 1) and is lighter than air. It burns in oxygen, producing water and nitrogen, and is a powerful base, combining with all acids to form salts. Ammonia is easily liquefied at ordinary temperatures, a pressure of seven atmospheres being sufficient; it is also the most soluble of gases, one volume of water dissolving over 800 volumes of it at ordinary temperature.

Ammonium Chloride.—Also known as *sal ammoniac* and as *muriate of ammonia.* A white solid obtained whenever hydrochloric acid and ammonia are brought together; it is usually produced by neutralizing the distillate from ammoniacal gas liquor with this acid, concentrating the resulting liquid. It is also found in volcanic deposits, and was the first ammonium salt discovered. It is largely used in electric work as the electrolyte in Leclanché primary cell.

Ammonium Chloride Cell.—A type of primary cell for open circuit work having zinc-carbon electrodes and an electrolyte of ammonium chloride (sal ammoniac). The Leclanché cell is an example of this type.

Ammortisseur.—An arrangement of copper rods in the pole faces of a dynamo so as to dampen the oscillations of the magnetic flux at the commutator, and thus reduce the tendency to sparking at the brushes.

Ammunition Hoist, Electric.—An electrical apparatus for hoisting ammunition to the guns of a warship.

Amorphous.—Having an uncrystalline structure; without determinate shape; structurally unshapen; unshaped; as, amorphous slag, etc.

Amperage.—The strength of an electric current measured in amperes.

Ampere.—The practical unit of electric current: it is the current produced by an electro-motive force of one volt in a circuit having a resistance of one ohm. An ampere is that quantity of electricity which will deposit .005084 grain of copper per second. It is one-tenth the absolute C. G. S. unit of current strength Current in amperes equals pressure in volts divided by resistance in ohms, or again, electro-motive force equals resistance multiplied by current; and again, resistance equals electro-motive force divided by the current: thus, it will be seen that these terms are dependent upon each other, and that their relation to each other is expressed by this law. These are written in three ways:

1. $C. = \frac{E}{R}$
2. $E. = C \times R$, or
3. $R. = \frac{E}{C}$

If one volt will force one ampere of current through a circuit having one ohm resistance it will take five volts to force five amperes through the same circuit. If this resistance should be increased to five ohms it would take five times five amperes for the proper number of volts to force the amperes through, which would be 25 volts. From this it can be seen that it is very easy to obtain any one of these quantities when we have the other two.

Ampère, André Marie—Born 1775, died 1836. A French physicist, distinguished for his researches in electro-dynamics. He first propounded the theory of electro-dynamics (1820), known as Ampère's theory. *Ampère* was the inventor of the astatic needle. He was the first to show that two parallel conductors carrying currents traveling in the same direction attract each other, while if traveling in opposite directions repel each other. He also formulated the theory that there were currents of electricity circulating in the earth in the direction of its diurnal revolution which attracted the magnetic needle and advanced the view that electricity and magnetism were identical.

Ampere Balance.—An ammeter in the form of a balance or scales. These balances are made with different capacities for different current strengths.

Ampere Centimeter.—The magnetic flux caused by a current of one ampere passing through a distance of one centimeter.

Ampere Foot.—A unit, in which the current strength in amperes is multiplied by the distance in feet to which the current is conveyed; used for estimating drop of voltage in the electric circuit.

Ampere Hour.—For commercial purposes, a larger unit of electrical quantity than the *coulomb;* it represents the quantity of electricity passed by one ampere of current in one hour; being equal to 3600 coulombs.

Ampere Hour Efficiency of Storage Battery.—The ratio of the ampere hours obtained from a storage battery to the ampere hours required to charge it; the *quantity efficiency* as distinguished from *the energy, or watt hour efficiency.*

Ampere Hour Meter.—A meter for determining the amount of electrical power consumed, measured in ampere hours.

Ampere Hour Output of Storage Battery.—The electrical output of a storage battery, measured in ampere hours.

Ampere Meter.—1. An instrument which measures the current strength directly in amperes. Also called *ammeter.*

2. The product of one ampere times one meter, *i. e.*, one ampere meter is a current of one ampere strength flowing through a conductor one meter long.

Ampere Minute.—A unit of electrical quantity representing the quantity of electricity passed by one ampere in one minute.

Ampère's Rule for Deflection of Needle.—"If one swims with the current and looks at the plus (+) or north seeking pole of a magnetic needle it will be deflected to the left, while the negative (—) or south seeking pole will be urged to the right."

Ampère's Theory of Magnetism.—A theory advanced by Ampere that around each *molecule of a magnetic substance* there circulates continually an electric current and that the process of magnetization consists in arranging these currents so that they all take the same direction.

Ampere Turns.—A total of magnetic force equal to the product of *the number of turns* in a magnetic coil by *the current strength* in amperes.

Ampere Volt.—A term sometimes used for the unit of electrical power; a *watt.*

Amperian Currents.—The currents conceived in Ampère's theory of magnetism to be constantly circulating around each molecule of a magnetic substance; atomic or molecular currents.

Amplitude of Simple Harmonic Motion.—The greatest distance of an oscillating point from its mean position.

Amplitude of Vibration.—The maximum value of a vibrating or wave motion on either side of its zero point.

Amygdaloid.—A trap rock of igneous origin and complex structure, deriving its name from little almond like pits of softer material found throughout the mass. In the Lake Superior region, copper bearing amygdaloids frequently show native copper in these pits or *amygdules.*

Amyl-acetate.—A distilled mixture of amyl-alcohol, sulphuric acid and sodium acetate. It is used as the illuminant in the Hefner-Alteneck amyl-acetate standard lamp.

Amyl-acetate Lamp.—A form of standard lamp employed in photometry, having a wick saturated with amyl-acetate adjusted to produce a flame of given height.

Amyloid.—A preparation for incandescent lamp filaments; it consists of a thread formed by a solution of cellulose, or a cotton thread which has been dipped into sulphuric acid and parchmentized or converted into a state resembling cellulose.

Amyloid Filament.—An incandescent lamp filament composed of an amyloid thread.

Analysis.—In chemistry, the resolution of a compound into its parts or constituent elements. Such analysis may be *qualitative,* showing the nature of the various bodies only, proving their presence by tests; or it may be *quantitative,* in which the exact proportions of the different constituents are ascertained by a series of refined eliminatory processes accompanied by weighing on delicate balances.

Analysis, Electric.—The resolving of a substance into its elements by means of electricity.

Anchor.—Tie wires employed in a trolley system for binding the trolley wire to the posts in order to give it the proper tension.

Anchored Filament.—A filament for incandescent lamps exposed to excessive vibration; as, on shipboard, railway cars, etc., which is so supported that it cannot suffer injury because of the vibration.

Anchor Log.—A log buried in the earth, or sunk in concrete, to act as an anchor for the guy wires of a telegraph pole.

Anchor Plug Receptacle.—A variety of wall socket for an incandescent lamp.

Anchor Strain Ear.—A trolley ear for holding an overhead trolley wire at the proper tension.

Anemometer.—An instrument for measuring the velocity of the wind; a wind gauge.

Aneroid Barometer.—An instrument for indicating atmospheric pressure. The action of the aneroid depends on the pressure of the atmosphere on a circular metallic box hermetically sealed and having a slightly elastic top, the vacuum serving the same purpose as the column of mercury in the ordinary barometer.

Angle.—The difference in direction between two intersecting lines.

Angle Box.—In conduit work, a metal box of rectangular cross section having its ends containing the outlets at right angles. The box is lined with an insulating material and is used for splicing or "pulling-in" conductors.

Angle of Declination.—The angle between the magnetic meridian of a place and its geographic meridian, as shown by the deviation of the magnetic needle; the *angle of variation.*

Angle of Dip.—The angle which a magnetic needle makes with the horizon when the vertical plane in which it turns corresponds with the magnetic meridian; the angle of inclination; *the dip.*

Angle of Inclination.—The angle formed by a magnetic needle with a horizontal line passing through the point of support of the needle, when the latter is free to move in a vertical plane. Also called *angle of dip.*

Angle of Lag.—In an alternating current circuit, an angle which shows the amount by which the phase of the active component falls behind the total current.

Angle of Lead.—1. The angle through which the commutator brushes are moved out of the normal plane, for the purpose of obtaining sparkless commutation.

2. In valve motion, the angle which a line, drawn through the centres of the shaft and crank pin, makes with the cylinder axis when *admission* begins. Used in valve motion analysis by the Zeuner diagram.

Angle of Torsion.—The angle through which one end of a body, as a silk fiber or wire, is twisted while the other end is held fast. The torsion, due to the twisting, forms the controlling force in the operation of some of the electrical measuring instruments.

Angular Acceleration.—The rate at which the angular velocity of a body increases per unit of time.

Angular Advance.—A term relating to steam engine valve gear. It is the acute angle made by a line passing through the center of the shaft and center of the eccentric, with a line passing through the center of the shaft and perpendicular to the line joining the center of the shaft and the center of the crank pin. Its magnitude depends on the lead and outside lap of the valve.

Angular Velocity.—The speed of a turning body, or one revolving in a vertical plane; as, a shaft or crank, usually described in circular measure, or as the number of *radians* passed through in one second. Thus, a wheel engine flywheel making three revolutions per second would have an angular velocity of 360 x 3 degrees or 360 x 3 ÷ 57.28 *radians.*

Anhydride.—A class of chemical compounds which are regarded as molecules of water from which the hydrogen has been taken and an acid or basic element has been substituted for the hydrogen.

Animal Electricity.—Several species of creatures inhabiting the water have the power of producing electric discharges by certain portions of their organism. The best known of these are the *Torpedo,* the

Gymnotus, and the *Silurus*, found in the Nile and the Niger. The Electric Ray is provided with an electric organ consisting of laminæ composed of polygonal cells to the number of 800 or 1000, or more, supplied with four large bundles of nerve fibres; the under surface of the fish is —, the upper +. In the Surinam eel, the electric organ goes the whole length of the body along both sides. It is able to give a very severe shock, and is a formidable antagonist when it has attained its full length of 5 or 6 feet.

Animal Magnetism.—A term formerly applied to hypnotism or mesmerism.

Animal Oils.—Lubricating oils for machinery obtained from animal tissues, the principal being sperm, ordinary whale, neatsfoot, seal. The animal oils do not dry and therefore do not gum, but they decompose and generate fatty acids which corrode metal work with which they come in contact and produce also residual deposits.

Anion.—The non-metallic radical, or ion which appears at the anode, or positive electrode, in an electrolytic cell; the *electro-negative component.*

Anisotropic.—Having different electrical, optical and other physical properties in different directions; opposed to *isotropic;* non-isotropic; æolotropic.

Anisotropic Conductor.—A conductor which has different conducting properties in different directions through its mass.

Anisotropic Dielectric.—A dielectric which is unequal in its electrical properties in different directions.

Anisotropic Medium.—A medium which produces different effects, in electrical or other qualities, in different directions.

Annealing.—The process of slowly cooling carbon steel after gradually heating it, so as to render it soft for working, the metal being usually protected from contact with the air. In hard steel the carbide of iron or *cementite* is in solution; in pure iron, heating causes the cementite to separate from the solution, and annealing permits the two constituents to remain separate, thus giving soft steel. The process of softening by heating and then slowly cooling, applicable to glass, iron, copper, etc.

Annealing Furnace.—A furnace in which metals are heated nearly to fluidity, and then allowed to cool slowly, so as to render them less brittle or to make them malleable; or, as with glass, a furnace in which the heat is retained for a considerable period in order that the process of cooling may be protracted.

Annealing Pot.—A closed pot set in a furnace, and used for exposing an object to heat without forming a scale of oxide. Pots for annealing wire are made ring shaped, so as to receive, with as little vacant space as possible, the wire which is coiled therein. The smaller the amount of air in the closed pot, the less the deterioration of the wire by exposure of its heated surface.

Annual Load Factor.—The ratio of the average daily out-put of an electric plant for one year to the maximum out-put at any one time.

Annual Variations.—The periodic variations of the earth's *magnetic declination* which occur each year.

Annular.—Pertaining to, or having the form of a ring; forming a ring; ringed; ring shaped.

Annular Magnet.—A ring shaped magnet.

Annular Space.—The ring like space contained between two concentric circles or cylinders.

Annunciator.—A fitting attached to an electric or pneumatic call system, in which a shutter, falling in one of a series of windows in a frame, discloses number of the telephone subscriber, apartment, etc., whence the call has been made.

Annunciator Clock, Electric.—An electric clock operating an annunciator, and closing certain circuits at set times.

Annunciator Drop.—A signal box containing a number of small shutters, the fall of any one of which, effected by the opening or closing of a circuit containing a particular electro-magnet, indicates whence the call was sent.

Anode.—1. The positive electrode in an electrolytic cell, the one by which the current enters, and which is dissolved away.

2. The positive electrode of a vacuum tube.

Anodic.—Pertaining to the conductor or plate of a decomposition cell connected with the positive terminal of a battery, or other electrical source.

Anodic Rays.—The radiation from the anode or positive electrode in a vacuum tube.

Anomalous Helix.—A helix, or solenoid, wound in such a manner about its core as to make an anomalous magnet.

Answering Board.—A separate panel at the lower part of a multiple telephone switchboard on which the answering jacks are mounted.

Answering Call Box.—A call box in which a signal is given to indicate that a call has been properly received at the station.

Answering Jack.—In a multiple telephone switchboard, an additional jack provided for each line on the particular section at which that line's drop is located, and placed in a separate panel in the lower part of the board.

Answering Plug.—In a multiple telephone switchboard, a contact plug which the operator introduces into an answering jack in order to ascertain from a calling subscriber the number of the subscriber wanted.

Antenna.—In wireless telegraphy, the receiving aerial or group of electric conductors supported on a lofty mast at the receiving station for gathering the transmitted waves and carrying them to the receiving instrument. Plural, antennæ.

Anthracite.—A hard coal containing 90 to 95% of carbon, and very little hydrocarbons, consequently burning without smoke, and a short flame. The different sizes of *screened* anthracite conl may be taken as follows: *egg*, $2\frac{1}{2}$-$1\frac{3}{4}$ins.; *stove*, $1\frac{3}{4}$-$1\frac{1}{4}$ ins.; *chestnut*, $1\frac{1}{4}$-$\frac{3}{4}$ inch; *pea*, $\frac{3}{4}$-$\frac{1}{2}$ inch; *buckwheat*, $\frac{1}{2}$-$\frac{1}{4}$ inch; *rice*, $\frac{1}{4}$-$\frac{1}{8}$ inch. *Lump* and *broken* coal are larger sizes than egg.

Anti-cathode.—In an X-ray tube, a second aluminum plate fixed near the middle of the bulb, upon which the rays from the cathode are focussed.

Anti-coherer.—In wireless telegraphy, a receiving instrument which dispenses with the principle of the coherer; as, for example, the electrolytic receiver or *responder* of the De Forest system.

Anti-friction Metal.—A term applied to the various tin-lead alloys used to line journal boxes of machinery; as, *white metal*, *babbitt metal*, etc.

Anti-hum.—A contrivance for reducing the humming noise occurring in an overhead wire as the result of vibration; it consists of a galvanized iron shackle set into the line and fitted with a cushion for deadening the vibration. A short piece of wire looped past it preserves the circuit intact.

Anti-inductive Load.—A term sometimes applied to a load in which the current leads the voltage across the load.

Antimonious Lead.—An alloy of antimony with lead sometimes used for making grids for storage batteries.

Antimony.—A metal, hard, brittle, resembling tin in its fracture, and of a color more resembling tin than lead. Its specific gravity is 6.6 and its melting point 842° F. (Authorities differ widely on this point.) It is used as a hardening ingredient in lead and tin alloys, such as *babbitt* and various other *anti-friction metals*.

Anti-nodes.—The points in wave motion which vibrate through the greatest amplitude, half-way between the points at rest, called *nodes*

Anti-parallel Feeding.—A method of supplying electric current to a system containing parallel connected electro-receptive devices in which a feeder runs to the opposite ends of each of the mains.

Anti-parallel System.—An electric distribution in which the current is admitted at the opposite ends of the two conductors of the circuit so as to produce a potential difference that is relatively even between the conductors.

Antique Brass.—A special finish given by platers to oxidized brass articles, whereby the portions in relief appear dull and old.

Anvil of Telegraph Key.—The metallic surface upon which the front end of a telegraph key descends under pressure of the operator's finger.

Aperiodic.—The quality of being devoid of periodic motion; as, when an index needle that has been deflected comes to rest without swinging.

Aperiodic Galvanometer.—A thoroughly damped or dead beat galvanometer, which gives its reading with only a slight oscillation of the needle before coming to rest.

Aperiodic Voltmeter.—A voltmeter in which an aluminum disk moving in the field of an electro-magnet is employed to damp the deflection of the needle.

A-pole.—A double telegraph pole resembling the letter A in shape; *an A-mast.*

Apparatus.—Things provided as means to some end, especially a full collection or set of implements, or utensils, for performing scientific experiments or operations; as, a telegraph apparatus.

Apparent Coefficient of Magnetic Induction.—The apparent permeability or ratio existing between the magnetization produced, and the magnetizing force producing such magnetization of a paramagnetic substance as influenced by the existence of eddy currents in the substance itself.

Apparent Efficiency.—The efficiency of a machine in an alternating current circuit considered with reference to its apparent power.

Apparent Power.—In a reactive alternating current circuit, the product of the amperes multiplied by the volts, as distinguished from the *true* power as indicated by a watt meter.

Apparent Resistance.—A term used to denote the opposition to current flow, or *impedance* in an alternating current circuit.

Apparent Watts.—In an alternating current circuit, the product of the virtual amperes multiplied by the virtual volts; the apparent energy or power.

Appliances.—Instrumental means, aids or devices; as the *appliances* of a trade; electrical *appliances*, etc.

Applied Mechanics.—The principles of mechanics as applied to constructing machinery; practical mechanics.

Apprentice.—One who is bound by indentures to serve an electrician, or other skilled workman, for a certain time, with a view to learning the trade, or occupation, in which his master agrees to instruct him.

Approximate.—Nearly approaching correctness, not carried out to perfect accuracy; as, *approximate* results, *approximate* figures.

Appurtenance.—That which belongs to something else; an adjunct or appendage, something annexed to another thing which is larger or more important; as, the vibrator of a secondary induction coil.

Apron Grapnel.—A grappling iron for picking up cables, having its hooks protected by a metallic apron which leaves just space enough between it and the ends of the hooks to admit the cable.

Aqua Ammonia.—Water which contains ammonia in solution.

Aquafortis.—Commercial *nitric acid*, consisting of 70% acid and 30% water. So called by the old alchemists (*strong water*), on account of its property of acting on metals.

Aqua Regia.—*Royal water*, a mixture of two parts nitric acid with four parts of hydrochloric acid, so called by the alchemists as it dissolves gold, "the king of metals."

Aqueduct.—A conduit or artificial channel for conveying water, especially one for supplying cities with water; also for power stations.

Aqueous Solution.—A solution having water as the solvent.

Arago, Dominique François.—Born 1786, died 1853. A French physicist, noted especially for his discoveries in electro-magnetism (1820). He obtained, in 1825, for his discovery of the development of magnetism by rotation, the Copley Medal of the Royal Society of London. His attention was devoted chiefly to astronomy, magnetism, galvanism, and the polarisation of light. In 1812, he began an interesting course of lectures on astronomy, which attracted all Paris.

Arago's Disk.—An apparatus to illustrate the effect of induced currents, as discovered by Arago in 1824. A copper disk is caused to rotate with great velocity under a magnetic needle, a sheet of glass being interposed to prevent air disturbances from the rotating disk. The needle is then seen to turn in the direction of rotation, and, if the speed of the disk be high enough, finally to rotate with it.

Arborescent Deposits.—Branching deposits occurring in electro-metallurgy, resembling trees in shape.

Arc.—1. In electric lighting, a stream of incandescent vapor connecting the terminals of a lamp when they have been drawn apart and having sufficient E. M. F. maintained between them. The luminosity of the arc is due partly to the vapor which contains volatilized particles from the terminals, and partly to the incandescence of the terminals themselves.

2. Any flashing occurring between the terminals of an electric circuit when the circuit has been interrupted.

3. Any portion of the circumference of a circle, the curved boundary of a segment, or that part of the circumference cut off by any angle.

Arc Blow Pipe.—A blow pipe in which an electric discharge is used to produce the blast of air.

Arc Circuit Cut Out.—A cut out set in an arc light circuit connected in series, to prevent the entire circuit from breaking when any lamp happens to go out.

Arc Circuit Cut Out Box.—A box containing an arc circuit cut out.

Arc Circuit Indicator.—A form of galvanometer for indicating the flow of current through an arc lamp circuit.

Arch.—A brickwork or masonry structure, built to a curved outline, with wedge-shaped pieces, which mutually support each other while the whole is supported at either end. The base of the semi-circle or semi-ellipse is the *springing line;* its length the *span;* the summit of the curve is the *crown;* its vertical height above the springing line the *rise;* the inner curve is the *intrados;* the outer curve is the *extrados;* the wedge shaped pieces are *voussoirs;* the crowning one which locks them, the *keystone;* the lowest from which they rise, the *springers.* A half of an arch is a *haunch* or *flank.* The supports have various names: *bearing walls,* if simple vertical walls; *abutments,* if they resist an oblique thrust; *piers,* if they are simple vertical columns or shafts. A *skew arch* is one that crosses a road or river at an angle.

Arch Gauge.—An instrument for measuring the pressure of illuminating gas, where the *index scale* is in the form of an arch.

Arcing.—Forming a voltaic arc; as, at the brushes of a dynamo, or in a broken circuit.

Arc Lamp.—A device for producing light by the voltaic arc. An automatic mechanism operated by both mechanical and electrical means, is used to regulate the carbon electrodes, so that they touch when no current is flowing and spring apart when the current is turned on. Arc lamps are divided into several classes; as, (a) lamps having fixed parallel carbons; (b) lamps without regulating mechanism; (c) lamps in which the whole current passes through the regulating mechanism; (d) lamps having the regulating mechanism and the carbons with their arc in parallel. Recent improvements have been made in arc lamps in which the arc itself has been made luminous, which have become known as "flaming arc lamps," while comparatively little light comes from the hot carbon tips, with an increased efficiency, nearly ten times as great as with the standard carbon arc lamps.

Arc Lamp Compensator.—A choking coil introduced into the circuit of an arc lamp to prevent sudden initial rush of current, to minimize variations in current strength, and in other ways regulate the current supplied to the arc; *an arc lamp resistance.*

Arc Lamp Cut Out.—A switch for cutting an arc lamp out of circuit.

Arc Lamp Spark Arrester.—A projector of wire gauze sometimes placed around the arc to guard against setting fire to neighboring combustible materials.

Arc Light.—The light of the voltaic arc. The term "arc" is applied on account of the bow like course taken by the flame between the terminals of the two electrodes, and "voltaic" because it was first produced by the use of the battery invented by Volta.

Arc Light Circuit.—A circuit, generally connected in series, containing arc lamps.

Arc Light Diffuser.—A name generally applied to a type of opaque, or nearly opaque reflector, that reflects the light of an arc lamp upward to the ceiling.

Arc Light Generator.—A series wound dynamo for supplying current to arc lamps.

Arc Light Meter.—A meter for measuring the electric current supplied for arc lighting purposes.

Arc Light Projector.—A reflector used in connection with an arc lamp for concentrating and projecting the light rays in a given direction.

Arc Light Regulator.—An automatic mechanism for keeping the carbons of an arc lamp fed towards each other as they waste away, so as to preserve the proper width of the arc.

Arc Light Tower.—A tower on which numerous arc lamps are supported for wide outdoor illumination.

Arc-light Transformer.—An induction coil having primary and secondary windings and an iron core; used in alternating current lighting for reducing the comparatively high pressure of the primary circuit to the low pressure of the secondary circuit. A transformer for this service will have a large number of turns of fine wire for the primary winding and a small number of turns of coarse wire for the secondary winding, the ratio of turns depending on the amount of voltage reduction required.

Arc of Contact.—1. That portion of the circumference of a pulley which is in contact with a belt or rope. Thus, with two pulleys of uniform size the belt will touch half the circumference of each, and the arc of contact for each pulley will be 180°.

2. In gearing, that part of the pitch line through which two engaging teeth pass while in contact.

Arc of Swing.—The arc, or portion of a circle described by the swing of a deflected index needle; as, of a galvanometer needle.

Arc Resistance.—The resistance to the flow of current offered by the voltaic arc. The resistance of the intervening air is so high that it causes great heating, and hence produces an intense light. If the carbons of a commercial lamp be one thirty-second of an inch apart, the resistance may be one and a half ohms.

Arc Standard Light.—A standard of light based upon the illuminating power of an arc light of definite proportions.

Arc Striking Mechanism.—The mechanism in an arc lamp by means of which the carbon points are separated upon passage of the current so that an arc may be formed between them.

Arc Switchboard.—A switchboard containing spring jacks in which various circuits terminate, with contact plugs joined to dynamo terminals, so that any dynamo or group of dynamos may be connected with any circuit or number of circuits.

Arc Welding.—A method of welding in which the metal to be united is fused by the heat of an electric arc.

Areometer.—An instrument for measuring the specific gravity of liquids. It is practically the same as the *hydrometer*, the only difference, if any, being that the areometer has the thermometer within its own stem, thus permitting temperature and gravity to be read from one instrument.

Argand Valve Burner.—An Argand gas burner provided with an appliance for both turning on and lighting the gas by electricity.

Argon.—A colorless gas much resembling nitrogen, which was discovered as a constituent of the atmosphere by Lord Rayleigh and Professor Ramsay in 1894. It is present in ordinary air to the extent of 0.9 per cent, and is the most inert substance known, as, up to the present, it has refused to combine with any other substance. Other recently discovered constituents of atmospheric air are "*krypton*" (= 0.01%), "*helium*," "*neon*" and "*metargon*," but comparatively little is known respecting them.

Armalac.—A trade name for an insulating varnish composed of black paraffin in a solution of petroleum naphtha prepared by a special process. It is free from acids, never becomes brittle, and will absorb oil without harmful effects.

Armature.—1. A piece of steel or soft iron, or a collection of such, so placed as to be acted upon by a permanent or electro-magnet.

2. In a magneto or dynamo, a core of metal around which is a wire winding, constructed to rotate near the poles of a magnet.

3. A piece of soft iron joining the poles of a horse shoe magnet to preserve the magnetism.

Armature Bars.—Heavy bars or strips of copper, used instead of copper wire as the generating conductors in certain large types of drum armature.

Armature Binding.—Coils of wire bound outside the windings of an armature to secure them against becoming loosened by the force of the rotation.

Armature Bore.—The opening between the pole pieces of a dynamo or motor within which the armature rotates; *the armature hole.*

Armature Chambers.—Spaces provided in the core of an armature to admit of the winding of the armature wires; *armature slots.*

Armature Circuit.—The path followed by the electric current through the windings of a dynamo or motor armature.

Armature Coil.—1. That portion of an armature winding passed over in following the course of the winding from one segment of the commutator to the next.

2. A section of armature winding prepared on a form to the exact shape re-

quired to fit into the slots of the armature core.

Armature Core—The inner laminated iron body of a dynamo armature on which the conducting coils are wound.

Armature Core Disks.—Disks punched out of sheet iron for building up *laminated* armature cores.

Armature Covering.—A cover, usually of canvas, for protecting an armature from dust or injury when not in use.

Armature Inductors.—The insulated coils or bars bound to the dynamo armature core, in which the electromotive forces are generated when the armature is rotated in the magnetic field; *armature coils*, or *windings*.

Armature Loop.—One loop of an armature winding.

Armature of Cable.—A name sometimes given to the outside sheathing of a cable.

Armature of Condenser.—A term used to denote the coatings or metallic plates of a condenser.

Armature of a Dynamo.—A metallic body made up of coils of wire wound around an iron core in which electric currents are induced by its rotation in a magnetic field. The principal types are the *ring* and the *drum* armature. The armature is the most vulnerable part of a dynamo, and being subjected while rotating, to various detrimental influences, is a prolific source of faults, some of which may be enumerated as follows: (*a*) Short circuits, (*b*) grounds in armature, (*c*) disconnections in armature circuit.

Armature of Holtz Machine.—Small tongues of paper, serving the purpose of replenishers, which project through the winders in the stationary glass plate.

Armature of Magnet.—A piece, or mass. of soft iron or steel placed across the poles of a horse shoe magnet to act as a "keeper," by which the magnetization is preserved.

Armature Pinion.—A pinion carried on the shaft of a motor which, together with a gear wheel, constitutes the reduction gearing.

Armature Pockets.—Recessed spaces in the core of an armature to admit the winding coils; *armature slots*.

Armature Projections.—Parts of the surface of a slotted armature which project beyond the windings sunk in the slots or bores.

Armature Reactions.—Certain reactions against the magnetic circuit of a dynamo which are established by the rotation of the armature.

Armature Slots.—Slots in the core of an armature to admit the winding coils; *armature pockets or chambers*.

Armature Spider.—A metallic frame with radial arms for supporting an armature upon its shaft.

Armature Stampings.—Disks stamped or punched out of sheet iron for building up armature cores; armature core disks.

Armature Turns.—The turns, or loops, of the armature windings.

Armature Varnish.—An insulating varnish sometimes used for coating the armature windings as a protection against moisture.

Armature Winding Space.—Recesses provided in an armature core for the armature windings.

Armored Cable.—A cable having, in addition to its insulating material, a protective sheathing of wire or metal tubing.

Armored Concrete.—Concrete which is *reinforced* or strengthened by the incorporation of suitably disposed steel bars and rods; the reinforcement being arranged to utilize the superior tensile strength of the metal, while the compressive stresses are designed to be borne by the concrete itself; also called, *reinforced concrete*.

Armored Conductor.—A conductor protected by a metallic sheathing.

Armored Hose.—Hose-pipe strengthened by an external protection of spirally coiled wire.

Armored Pump Valves.—India-rubber valves moulded upon an internal disk of sheet steel. The disc is stamped with notches and projections, and copper plated to secure the adhesion of the rubber, which is vulcanized after moulding.

Armor of Cable.—The metallic sheathing provided for the protection of *submarine or other cables*.

Arms of Balance or Bridge.—The three known resistances which, together with the unknown resistance to be measured, form the system of conductors in a *Wheatstone bridge.*

Armstrong, Sir Wm. G.—Born at Newcastle-on-Tyne, Nov. 26, 1810, son of William Armstrong, a merchant. He was sent to school first at Whickam, thence to the grammar school. He invented a *hydro-electric* machine for the production of high-tension electricity which made him famous, also leading to his being elected fellow of the Royal Society, in 1843, being proposed by Faraday. His hydraulic inventions, including a crane and accumulator, met with much success. In 1854 he invented a gun with which his name is popularly associated.

Army Telegraph.—A telegraphic outfit suitable for field use during military operations.

Arrester Plate.—One of the metallic plates of a comb lightning arrester, especially the one connected to ground.

Arrhenius.—Noted for his theory that a substance whose aqueous solution is capable of conducting electricity, is broken up into parts or ions charged some with positive others with negative electricity. This theory is known as the theory of electrolytic dissociation. In 1903 he received the Nobel prize for achievements in the field of chemistry.

Arrival Curve.—In submarine cable working, a curve illustrating the slow growth of the current at the end of the line. This slow growth is largely obviated by the use of *condensers.*

Arriving Current of Telegraphic Circuit.—The current at the remote end of a telegraphic line at the point where the wire meets the earth.

Artificial Cable.—In duplex submarine cable working, a series of resistance coils combined with condensers to produce a balance in resistance and capacity with the real cable, and corresponding to the artificial line in overland telegraphy.

Artificial Carbons.—Manufactured carbon rods for arc lamps. There are a great variety of methods of manufacture; but, in general, graphite from gas retort carbon is used as the basis, being ground up and mixed with pure carbon powder, after which a paste is formed by the use of some adhesive mixture, and the rods are shaped by moulding, squeezing or forcing through a die plate.

Artificial Fault in Cable.—A fault intentionally created in a cable for the purpose of making experimental tests.

Artificial Illumination.—Lighting by artificial means.

Artificial Line.—In duplex telegraphy, a set of coils of fine wire of high resistance designed to balance the resistance of the main line; *a rheostat* or *resistance box.*

Artificial Magnet.—A magnet which has magnetism acquired by an artificial process of magnetization, as distinguished from a *natural* magnet or *magnetite*; sometimes called *lodestone.*

Artificial Stone.—A mass resembling concrete, but saturated with an impervious material, which is moulded into paving-flags, steps, balustrades and such trimming or finishing pieces as lintels, quoins, window sills, door steps, etc.

Asbestos.—A fibrous variety of ferro-magnesium silicate, the fibers being usually so fine as to be flexible and easily separated by the finger. It is found in Italy, Canada, Cape Colony, United States and elsewhere. Asbestos is extremely incombustible and its fibrous nature permits it to be spun into yarn, which may be plaited to form piston rod packings, etc.

Asbestos Cartridge.—A fireproof covering for the fuse in cut outs, encasing the fuse from ferrule to ferrule. As soon as the fuse blows, the asbestos closes the path and renders an arc impossible.

Asbestos Porcelain.—A porous compound containing asbestos and resembling porcelain, for making the porous jars for voltaic cells.

Ashes.—A general term for the unburnt matter remaining after the combustion of any fuel, it comprises incombustible mineral constituents, dirt admixed with the fuel, and some unconsumed fuel. The nature of the ashes depends upon that of the fuel and the method of combustion.

Ash Pit.—The space beneath the fire bars in a furnace. As normally made, it constitutes a *dry ash pit;* when a trough is placed below the bars to cool them by evaporation of a sheet of water, it is said to be a *wet ash pit.*

Asphalt.—This name is given to three diverse, allied substances: (1) The base or ultimate results of changes in those petroleums or natural hydro-carbons which do not contain paraffin, (2) natural deposits of bitumen, originally derived from petroleums, which are found in the form of self renewing lakes in Trinidad (W. I.), Venezuela, and elsewhere; (3) limestone rock, impregnated with 8 to 20% of bitumen, is found in the Val de Travers, in Switzerland. The derivative from petroleum is often termed *mineral pitch*, and serves as a waterproof paint, an anti-corrosive covering, etc. Asphalt is often used in cable conduits as it resists moisture, is ductile and can be readily and cheaply repaired.

Aspirator.—A device closely resembling an ejector, in which water passes through a nozzle, whose outlines conform to the *vena contracta*. This device induces a suction current in a connecting pipe and exhausts the air, thus creating a high vacuum. The *steam ejector*, used in connection with the vacuum brake, is also a type of aspirator.

Assay.—In metallurgy, the act or process of ascertaining the proportions of a particular metal in an ore or alloy; especially, the determination of the proportion of gold or silver in bullion or coin.

Assembling.—The bringing together of the parts of a machine or device. The combination of the various pieces forming a small intricate article, such as a rifle or typewriter, is properly known as *assembling;* the word *erecting* conveys the idea of building a large machine or structure with stagings, blocks and tackles, etc.

Assort.—To separate and distribute into classes; as, things of a like kind, nature or quality, or which are suited to a like purpose; to classify; as, to *assort* goods.

Assumed Direction of Current Flow.—The direction which an electric current is assumed to take, *viz.*, from the positive pole of an electric source out through the circuit, and back to the negative pole.

Assymmetry.—The state of being unsymmetrical, or devoid of symmetry.

Astatic.—Deprived of directive power; a term used especially of a magnetic needle which has had its directive power neutralized.

Astatic Couple.—Two magnets of uniform power so placed as to counter-balance each other's magnetic force.

Astatic Galvanometer.—A very sensitive galvanometer which neutralizes the effect of the earth's magnetism by the use of *astatic* needles.

Astaticize.—To eliminate all magnetic directive power due to the earth's magnetism.

Astatic Multiplier.—A name sometimes given to a galvanometer having an astatic needle or circuit.

Astatic Needle.—A form of magnetic needle for use in sensitive galvanometers; it consists essentially of two needles of equal size and strength bound together, one above the other, in reversed positions so that each counter-balances the effect of the earth's magnetism upon the other.

Astatic Suspension.—A method of suspending the needle of a galvanometer so as to overcome the effect of the earth's magnetism.

Asymptote.—A line which approaches nearer and nearer to a given curve, but never meets it; as, the axis of the hyperbola.

Asynchronous.—Not coinciding with respect to time; not occurring simultaneously. *Non-synchronous.*

Asynchronous Motor.—An alternating current motor which does not run *in step* with the alternations of the current. Also called *induction motor*.

A. T.—Abbreviation for *ampere turn.*

Atmosphere.—The air in which we live and which we breathe, whose weight presses on our bodies internally and externally and so is not perceived. Besides oxygen, nitrogen, argon, etc., there is present in the atmosphere about 0.04% by volume, of carbon dioxide, a variable amount of aqueous vapor, ammonia in various forms, and solid matter or dust. The pressure of the atmosphere at the sea level is about 14.7 pounds per square inch; for a rough approximation it may be assumed that the pressure decreases ½ pound per square inch for every 1000 ft. of ascent.

Atmospheric Electricity.—The free electricity always found in varying quantities in the atmosphere. The phenomena of atmospheric electricity are of two kinds; there are the well-known manifestations of thunderstorms; also, the phenomena of continual slight electrification in the air,

best observed when the weather is fine; the auroras constitute a third branch of the subject.

Atom.—The chemical unit, imagined as an extremely minute particle of matter, constituting the smallest quantity of an *element* which is capable of existing, and therefore deemed indivisible.

Atomic.—Relating to the atom.

Atomic Attraction.—The tendency in atoms to unite with other atoms and form molecules.

Atomic Heat.—The product resulting when the atomic weight of a substance is multiplied by its specific heat.

Atomic Theory.—The theory of the constitution of matter which asserts that all substances are composed of infinitesimally small particles or atoms. The atom of each elemental substance possesses properties peculiar to itself which govern the manner in which the element enters into combination with others to form a molecule.

Atomic Weight.—A relative weight assigned to the atoms of the various elements, representing: (1) Its weight as compared with that of an atom of hydrogen, (2) the smallest quantity by weight of the element that can enter or leave a compound, the combining quantity of hydrogen equaling unity; (3) the specific gravity of the body, as compared with hydrogen, when in a state of gas or vapor.

Atomize.—To separate a jet of any liquid into a finely subdivided spray, resembling liquid dust; effected either by hydrostatic pressure or by a blast of compressed air or steam in conjunction with specially shaped nozzles.

Atomizer.—An instrument, utilizing the principle of induced air currents, to discharge the liquid it contains in a fine spray.

Atomizing Carburetter.—A type of carburetter for internal combustion engines, in which the liquid fuel is converted into a fine spray and mixed with the proper proportion of air; known also as *spray carburetter*.

Atom of Electricity.—The electric charge possessed by an atom of matter.

Attachment.—1. That by which one thing is attached to another; connection.

2. Something attached, some adjunct attached to an instrument, machine or other object.

Attachment Plug.—A plug with suitable contacts for readily connecting a conductor into a socket.

Attenuate.—1. To make thin or slender; as, by mechanical or chemical action upon inanimate objects, or by the effects of starvation, diseases, etc., upon living bodies.

2. To lessen the amount, force or value of; to make less complete; to weaken.

Attracted Disc Electrometer.—A form of absolute electrometer, consisting of two plane metal disks, one poised horizontally at a small distance above the other and surrounded by a guard ring placed in metallic contact with it by a fine wire, the other supported on an insulated stand; the attraction of the lower plate upon the upper may be measured by changing the distance of the lower, by a micrometer screw, until the electric attraction balances the forces which act to raise the upper disk above the guard ring.

Attraction.—An invisible power in a body by which it draws anything to itself; the power in nature acting mutually between bodies or ultimate particles, tending to draw them together or to produce their cohesion or combination, and conversely resisting separation. *Attraction* is exerted at both *sensible* and *insensible* distances, and is variously denominated according to its qualities or phenomena.

Attraction of Gravitation.—That force which draws a body toward the center of the earth, commonly called the *weight* of the body. The force of gravity is represented by the letter g, which stands for the acceleration per second of a falling body due to gravity, the value of g increases with the latitude and decreases with the elevation. For all ordinary calculations for the United States g is generally taken at 32.16; *i. e.*, the acceleration of a falling body due to gravity $= g = 32.16$ ft. per second in one second.

Attractive.—Having the power or quality of attracting or drawing; as, the *attractive* force of a magnet.

Audible Code.—A code of telegraph signals intended to be read by sound, as in *acoustic telegraphy*.

Audible Signal.—A telegraphic signal to be received by ear, as distinguished from the *visual* signal which is to be read by the eye; *an acoustic signal*.

Audiometer.—An electrical apparatus for gauging and recording the delicacy of the sense of hearing.

Audiphone.—A fan shaped instrument, usually of thin hard rubber, which, when held against the upper teeth, conveys sound vibrations to the auditory nerve, and thus aids the hearing.

Audit.—1. An examination in general. An examination of an account or of accounts with the hearing of the parties concerned by proper officers, or persons appointed for that purpose, who compare the charges with the vouchers, examine witnesses, and state the result.

2. A statement of accounts; a balance sheet.

Auditor.—A person appointed and authorized to audit or examine an account or accounts, compare the charges with the vouchers, allow or reject charges, and state the balance.

Auget.—1. A small trough to drain the passage leading to an explosive mine, thus keeping the train dry.

2. A damp proof tube or trough leading to the explosive in blasting.

Auriferous.—Bearing or containing gold; from the Latin word *aurum*, gold; as, auriferous deposits or ores.

Aurora.—Sheets, streamers or streaks of pale light often seen displayed in the skies of the northern and southern hemispheres in the direction of the polar regions; *the aurora borealis and the aurora australis.*

Aurora Australis.—Lights similar to the *aurora borealis*, seen at night in extreme southern latitudes; *the southern lights.*

Aurora Borealis.—Luminous phenomena often observed at night in northern latitudes in the direction of the magnetic north, and attributed to disturbances of an electric nature; *the northern lights.*

Aurora Glory.—The crown shaped arc of light observed in the heavens during the occurrence of the aurora.

Auroral Arch.—An arch of light sometimes formed by the aurora.

Auroral Bands.—Parallel streamers of light often observed in connection with the aurora.

Auroral Corona.—A crown like form sometimes taken by the light of the aurora.

Auroral Curtain.—A broad sheet of auroral light resembling a curtain.

Auroral Flashes.—The light of the aurora occurring in intermittent flashes.

Auroral Storm.—A magnetic storm accompanying the appearance of the aurora.

Aurora Polaris.—A general name for the northern and southern lights.

Auto.—1. A combining form or prefix meaning *self.*

2. The familiar contraction for *automobile.*

Auto-coherer.—In wireless telegraphy, a type of coherer with automatic action for releasing the particles that cling together when the circuit is made. A globule of mercury in light contact with particles of carbon or iron produces the desired effect.

Auto-excitation.—Self-magnetizing of the field magnets of a dynamo. Also called *self-excitation.*

Autogenous Soldering.—The art or process of *lead burning*, whereby two pieces of lead are fused together by means of a *hydrogen flame.*

Autogenous Welding.—A method of welding, in which the metal is united by the fusion of its own substance without the introduction of any other flux. It is performed by the oxy-hydrogen blow pipe.

Auto Igniter.—A small magneto or dynamo for electric ignition of gasoline and petroleum engines, the armature of which is geared to the flywheel, thus supplying electricity as long as the engine revolves, and doing away with batteries, etc.

Automatic.—Self-acting; especially applied to machinery in which certain movements commonly made by hand are made by the machine itself.

Automatic Argand Burner.—An Argand burner fitted with an electrical arrangement whereby it may be lighted or put out automatically.

Automatic Call Box.—An apparatus fitted to a public telephone instrument by

which a person may secure its use by simply dropping a fee into the box.

Automatic Chemical Telegraphy.—Automatic telegraphy employing a chemically prepared paper ribbon on which the messages are recorded.

Automatic Circuit Breaker.—An automatic device for breaking a circuit when the strength of the electric current exceeds a given limit.

Automatic Contact Breaker.—An automatic device operated by an electro-magnet for opening and closing an electric circuit in quick succession; a vibrating contact.

Automatic Cut In.—An electrical adjustment for automatically connecting any electrical device into a circuit at the required moment.

Automatic Cut Out.—An electrical adjustment for automatically removing any electrical part or connection from a circuit at the required moment.

Automatic Cut Out for Battery.—An automatic switch connected with a storage battery for cutting out the charging current in case the pressure falls dangerously low.

Automatic Cut Out for Series Arc Lamp.—An arrangement by which an alternative path of low resistance is introduced when the circuit through the lamp becomes interrupted from any cause.

Automatic Cut Out for Series Incandescent Lamp.—A device which acts automatically, when the circuit through a lamp is broken, and short circuits it.

Automatic Electric Bell.—A bell having an automatic contact breaker, so that it keeps ringing as long as the circuit is closed; a vibrating or *trembling bell.* Generally, it is worked by a current exciting an electro-magnet, attracting or releasing an armature which is attached to the vibrating or pivoted tongue of the bell. This is done alternately so that the tongue beats against the bell. When the current is turned on it attracts the armature; as this moves towards the poles of the magnet it breaks the circuit by drawing the "contact spring" away from the "contact point." The movement of the armature causes the hammer on the end of the lever to strike the bell. A spring draws the armature back to its original position and the cycle repeats, thus causing a continued ringing.

Automatic Electric Gas Burner.—A device for electrically lighting the gas by the pressure of a button, and extinguishing it by the pressure of another button.

Automatic Electric Railway Signal System.—A system of electric signals for preventing trains from approaching each other too closely while running upon the same track; *the block system.*

Automatic Engine.—A term applied to a steam engine in which the cut off is varied, according to the load, by means of the governor.

Automatic Fire Alarm.—A device for automatically giving an alarm of fire when the heat increases beyond a certain point.

Automatic Fire Annunciator. — An annunciator which indicates automatically the location of a fire in response to an alarm.

Automatic Gas Cut Off.—In an electric gas lighting system, a device for cutting the battery out of the circuit when a fault occurs.

Automatic Ignition.—Ignition of the charge within an internal combustion engine, by the heat of compression.

Automatic Indicating Grapnel.—In submarine cable work, a grapnel fitted with electrical connections so that it gives a signal upon the cable ship the moment the cable is caught.

Automatic Inker.—In telegraphy, a siphon recorder which acts automatically.

Automatic Lubrication.—A term applied to devices designed to supply a *regulable* feed of lubricant for various wearing parts; as, in *sight feed, worsteds, chain oiling,* etc.

Automatic Machine.—A machine tool, whose parts and whose various movements are so co-ordinated with each other that it requires no further attention, after first setting or adjusting the various parts, than to supply it with material, lubricate it, or apply or shut off the power. The hollow spindle lathe, with stops, capstan rest, wire feed, etc., is a good example of this type. Where an attendant or operator is necessary, the machines become *semi-automatic.*

Automatic Make-and-Break.—1. A device actuated by an electro-magnet for

automatically closing and opening a circuit.
2. A low tension ignition device in which the make-and-break electrodes are operated by an electro-magnet; a *magnetic spark plug.*

Automatic Oiler.—An oil cup so adjusted as to automatically apply oil to the bearings of a machine while running.

Automatic Overload Switch.—An automatic switch set into the discharging current of a storage battery, which opens the circuit when an excessively high current is being drawn from the cells.

Automatic Paper Winder.—A reel for automatically winding the paper ribbon of a telegraph recorder.

Automatic Prepayment Telephone.—A public telephone set, containing a mechanism by means of which a coin, deposited in a slot, registers prepayment before the line can be used.

Automatic Regulation.—A method of making a dynamo self-regulating so as either to send a constant current through the external circuit under varying resistances, or to maintain a constant potential difference at its terminals under like variations of resistance. In cases where an approximately constant current is to be maintained in a circuit, as in series arc circuits, the adjustment of the resistance of the variable shunt is, as a rule, effected automatically by means of some electromagnetic device, actuated by solenoids placed in the main circuit.

Automatic Regulation of Motor.—A self-regulation of a motor for the purpose of preserving its speed constant.

Automatic Regulator.—An electro-magnetic device, actuated by solenoids placed in the main circuit, and used to maintain an approximately constant current; as, in *series arc circuits.*

Automatic Repeater.—In telegraphy, a repeater or translator working automatically instead of by hand.

Automatic Signaling.—Sending telegraphic messages by machines instead of by hand; *automatic telegraphy.*

Automatic Switch.—A switch which opens and closes automatically at required times. One form of switch used as a cut out for dynamos consists of an electro-magnet, fixed upon a slate base, and an iron armature fixed to the ends of the pivoted levers of the switch. The electro-magnet is included in series with the switch and armature circuit, and while the pressure of the machine to which the instrument is connected remains at its normal value, the current flowing in its coils is sufficiently strong to enable it to hold up the iron armature against its pole pieces. If from any cause the voltage of the machine is reduced, the current flowing in its armature is decreased also, until when it falls below a certain minimum value at which the automatic switch is arranged to act, the strength of the electro-magnet has been so far diminished that it can no longer hold up the armature against the weight of the levers, and these latter therefore drop and switch the machine out of circuit.

Automatic Switch for Incandescent Lamps.—1. A safety fuse.
2. A switch for turning an incandescent light on and off from a distance.

Automatic Synchronizer.—A phase indicator consisting essentially of two solenoids acting on cores on opposite ends of a rocker arm.

Automatic Telegraph Transmitter.—A transmitter for automatic telegraphy, consisting of a clockwork or other mechanism which draws a strip of paper perforated with the message under a series of contacts.

Automatic Telegraphy.—A method of telegraphy by which messages, previously perforated upon a strip of paper, are transmitted automatically by passing the strip under suitable contacts.

Automatic Telephone Exchange.—A method of making connections between telephone subscribers by switches operated from the subscribers' instruments, and thus doing away with the services of an exchange operator

Automatic Telephone Hook.—The hook upon which the telephone receiver is hung when not in use, and which being depressed by the weight of the receiver automatically disconnects the instrument, making connections again when the receiver is lifted off and the hook rises.

Automatic Telephone Switch.—The switch operated automatically by the raising or lowering of the hook on which the receiver hangs when not in use.

Automatic Time Cut Out.—An automatic device for effecting disconnections in a circuit at a set time.

Automatic Variable Resistance.—A resistance capable of making automatic variations in strength.

Automobile.—A self-propelled vehicle designed to run upon ordinary roads, transporting passengers and commodities beyond those necessary for its own consumption and guidance. The classification of motor carriages is usually by their bodies, the customary terms of the coach builders being frequently employed. A *runabout* is a small vehicle accommodating, generally, two persons; a *touring car* is a larger vehicle, seating four or more, with fittings for extended trips; a *limousine* has the rear seats enclosed within a carriage body, the driving seat being protected by a canopy; a *tonneau* is a rounded barrel-shaped accommodation, frequently with a rear entrance.

Automobile Torpedo.—A torpedo fitted with mechanism for self-propulsion through the water.

Auto-reversible Tele-radiophone.—A photophone capable of sending a number of messages at once, either in the same direction or in opposite directions.

Auto-telegraphy.—A method of transmitting telegraphic messages by the motion of a fillet of paper which has perforations corresponding to the length and order required to form the characters to be transmitted.

Auto-telephone System.—A system of telephoning with a single battery by which several subscribers can be placed in communication without the intervention of an exchange.

Auto-transformer.—A variable compensator in which a choking coil is introduced across the alternating current supply circuits so that varying currents can be obtained from different points on its windings; a one coil transformer, any part of which may be used as a primary and any part as a secondary.

Auxiliary Alarm Telegraph.—A provision in fire alarm signaling to prevent the repetition of signals over all the circuits from interfering with other incoming signals.

Auxiliary Bus Bar.—A bus bar in a central station connected with a pressure other than the central station pressure.

Average Efficiency of Motor.—The relation of the mechanical energy delivered by a motor during a certain time to the electrical energy required to drive it for that time.

Average Life of Incandescent Lamps.—The average time during which several incandescent lamps connected with a current of known strength will furnish light before the filaments break.

Average Pressure.—1. The mean load, in lbs. per square inch, upon a piston throughout its stroke; usually taken as the product of the mean of ten equally spaced ordinates of the indicator diagram multiplied by the scale of the indicator spring which was used in taking the card; also called, *mean effective pressure.*

2. The mean result of a series of pressures observed at regular intervals.

Avogadro's Law.—A law of physics, that at the same temperature and pressure equal volumes of different gases contain the same number of molecules. Hence, the molecular weights of gases are proportional to their densities.

A. W. G.—Abbreviation for *American wire gauge;* the Brown & Sharpe wire gauge.

Axes of Co-ordinates.—Two intersecting lines, one vertical, called the axis of ordinates, the other horizontal, called the axis of abscissas, by means of which the location of a point in a plane may be determined. The angle of intersection of the axes is usually taken as a right angle in which case the axes are said to be *rectangular;* with any other angle the axes are called *oblique.*

Axial.—Of or pertaining to, or constituting an axis, or *central line;* rotating on or about an axis.

Axial Current.—A current which has the same direction as the lines of magnetic force.

Axial Flow.—A term applied to that class of turbine in which the fluid passes through the motor in a direction parallel to its axis, like the Jonval or Parsons. Also termed *parallel flow.*

Axial Pitch.—In machinery, the pitch of a screw measured in a direction parallel with the axis. The term is specially applied to many-threaded screws to distinguish the pitch of a single turn only, from that termed divided axial pitch and from the common pitch.

Axis.—1. The straight line, real or imaginary, passing through a body on which it revolves, or may be supposed to revolve.

2. A straight line with respect to which the different parts of a magnitude are symmetrically arranged; as, *the axis of a cylinder*, i. e., the straight line joining the centers of the two ends; *the axis of a cone*, i. e., the straight line joining the vertex and the center of the base; the *axis of a circle*, any straight line passing through the center. Plural, *axes*.

Axis of Abscissas.—The horizontal axis of co-ordinates.

Axis of Ordinates.—The vertical or inclined co-ordinates.

Axle.—Generally speaking, a shaft connecting the naves of the opposite wheels of a vehicle. In railway use, an axle is a bar of circular section, to which the wheels are rigidly secured, and which revolves in suitable bearings. In automobiles, the axles may be dead, or stationary, the wheels revolving freely on them; or else *live*; that is, driven themselves by the motor.

Ayrton, William Edward.—Born 1847, died 1908. An English physicist and electrical engineer. Beginning his work in the government telegraph service in India, he afterwards studied under Lord Kelvin, returning to India in 1868 to continue telegraphic work. At this time he invented the method of locating a fault in a cable by taking measurements from one end of it only. In 1872, under Lord Kelvin, he superintended the construction of the G. W. telegraph cable. The next year he went to Japan to teach physics and telegraphy, and after that associated with Prof. Perry. He carried on electrical work that greatly benefited the science of electrical engineering, especially in designing electrical measuring instruments.

Ayrton Galvanometer Shunt.—A shunt devised by Ayrton and Mather in 1894, in which the coils are so arranged that their relative multiplying powers, whatever may be the actual resistance of the galvanometer, are always the same, so that it can be used with any galvanometer; the *universal shunt*.

Azimuth.—1. In determining the location of distant objects; as in astronomy, the arc of the horizon intercepted between the meridian of a place and a great circle passing through the zenith and the object observed.

2. The quadrant of an *azimuth circle*.

Azimuth and Range Telegraph.—A telegraph employed on a warship for signaling to the gunners both the azimuth and range of the enemy's position.

Azimuth Circle.—A great circle passing through the zenith, or point directly overhead, and the nadir, or point directly underneath, cutting the horizon at right angles.

Azimuth Compass.—A compass resembling the mariner's compass, but having the card divided into degrees instead of rhumbs, and having vertical sights, used for taking the magnetic azimuth of a heavenly body, in order to find, by comparison with the true azimuth, the variation of the mariner's needle.

Azimuth Dial.—A dial whose stile or gnomon is at right angles to the plane of the horizon; used in navigation and surveying.

Azimuth Telegraph.—A telegraph employed on a warship for signaling to the gunners the *azimuth* of the enemy's position.

Azote.—The French name for *nitrogen*, frequently encountered in scientific articles translated from that language. *Azotic acid* is nitric, *azote of potash* is potassium nitrate, etc.

B.—1 Abbreviation for Beaumé, referring to the *hydrometer scale.*

2. The symbol for *magnetic induction.*

B. A.—An abbreviation for British Association. Used as a prefix to standards adopted by the Association.

B. A. Ampere.—The standard ampere fixed by the British Association for the Advancement of Science.

Babbitting.—The application of Babbitt metal to the bearings of machinery to diminish friction. *Having two dissimilar metals always reduces friction.*

Babbitt Metal.—An alloy, named for its inventor, composed of tin, copper and antimony in varying proportions, used for bearings of machines; also known as *white metal*, and *anti-friction metal.*

Back Ampere Turns.—Ampere turns or windings on the armature of a dynamo which act in opposition to the magnetic flow set up between the field magnets.

Back Draft.—A rush of flame or smoke from the door of a furnace, occasioned by obstruction in the chimney.

Back Electro-motive Force.—A term sometimes used for counter electro-motive force, or that electro-motive force which opposes or tends to set up a current in reverse direction, to the impressed current.

Back End of Armature.—The end of a dynamo or motor armature opposite to the commutator or front end.

Back Induction.—An induction acting upon a magnetic field tending to demagnetize or weaken it.

Backing Metal.—The metal used for backing up the thin copper shell of an electrotype.

Backing Pan.—The shallow iron pan in which an electrotype shell is set for the "backing up" process.

Back Lash.—1. In machinery, the reaction or striking back of a piece of machinery, wheel, piston, etc., when the power makes a temporary pause, or a change of motion occurs. It is a consequence of bad fitting or wear, and in the latter case, indicates that the parts should be set up.

2. A shop term for the lost motion caused by the wearing of screw threads, knuckle joints, etc.

Back Magnetization of Armature.—Magnetic forces in the field windings of a dynamo which oppose or weaken the current delivered by the armature.

Back Pressure.—In a steam engine, the pressure on the opposite side of the piston, which opposes a resistance to the working stroke of the steam. This back pressure may be due to the pressure in a receiver, as in the high pressure cylinder of a compound engine: to that of the atmosphere, as in a non-condensing engine: or to that of an imperfect vacuum, as in a condensing engine.

Back Pressure Valve.—A valve designed to prevent the reflux of liquids or fluids in a pipe; a check or non-return valve.

Back Shock.—When a charged conductor is suddenly discharged, the induced charges of opposite sign in neighboring bodies may also discharge into the earth or into other conducting bodies. This back shock is sometimes felt by persons standing on the ground when some distant object has been struck by lightning. Also called, *return shock.*

Back Stop of Key.—A metal stop upon which the back of a telegraph key rests when released.

Backward Eccentric.—In steam engineering, that eccentric, of the pair which constitute a link motion, which drives the valve gear when the motion of the engine is reversed, that is, when it is in *backward gear.*

Backward Induction of Armature.—Induction occurring in a dynamo armature counter to that produced by the field magnets.

Backward Pitch.—A left handed pitch of the armature windings as seen from the commutator end.

Backward Wave.—A wave of electrical potential that is conceived of as setting out from the negative pole of a dynamo or other generator, and taking its course through a circuit in direct opposition to the electromotive force produced at the positive pole.

Bad Earth.—A name given to a condition of the ground which renders it a poor conductor of electricity.

Badigeon.—1. A mixture of plaster, stone powder and coloring matter, mixed with water to a paste, used for stopping holes, cracks and bad places in stonework.

2. Also a compound of sawdust and glue for repairing defects in woodwork.

Baffle Plate.—A thin plate or diaphragm used to deflect or retard the course of gases, etc.; as, the baffle plates inside a furnace door or those fitted on the tubes of a water-tube boiler.

Bain, Alexander.—Born 1810, died 1877. A Scottish electrician and inventor. He came to London as a journeyman in 1837, and thereafter perfected a number of electrical inventions. These included electrically operated clocks; an earth battery (1843); an apparatus for registering a ship's progress (1844); and the automatic chemical telegraph (1846). It is with the last invention that his name is chiefly associated, and because of the great impetus it gave to telegraphy he is entitled to the credit of being the pioneer of the modern high speed telegraph.

Bain's Chemical Recorder.—A mechanism for recording a telegraphic message in colored dots and dashes upon a strip of sensitized paper by the electrolytic effect of the current upon the chemical solution with which the paper is saturated.

Bain's Printing Solution.—The solution employed by Bain in chemically preparing paper for his chemical recorder.

Bain Telegraph Code.—An early telegraph code adapted for use in Bain's automatic system.

Balance.—1. In physics, a state of equilibrium or counterpoise; said to exist when the forces and momentum of a mechanism are so adjusted that motion is uniform and unattended by vibration or percussion.

2. A delicate form of scales adapted for the minute measurements of chemical and experimental work. One in the Royal Mint in London is so delicate that it shows the difference in weight occasioned by writing one's name with pencil on a previously weighed piece of paper.

Balance Beam Meter.—A prepayment electricity meter consisting of a balance lever or beam at one end of which is attached a copper plate immersed in a solution of copper sulphate contained in a copper box. Cups to hold, respectively, the coins that come in through the slot, and the weights which the collector substitutes for the coins when he collects them, are attached to the lever midway between the fulcrum and copper plate. At the other end of the lever a weight is attached which balances the copper plate and cups. The action of the meter depends on the electrolysis of copper sulphate with copper electrodes. When a coin is placed in the slot it falls into the cup and its weight brings down the arm and copper plate. This automatically completes a circuit, when the current is used causing copper to be deposited on the copper box from the copper plate until the latter has lost sufficient weight to bring the lever again into balance which breaks the circuit thus cutting off the current supply.

Balance Box.—The weighted box running on the projecting tail of a crane, which serves to balance the load.

Balance Crane.—In machinery, a crane in which the load is counterbalanced by a weight attached to the tail or hinder end, the amount of weight depending on the distance to which the load is lifted, the length of the tail, and the disposition of the mass of the crane itself. Balance cranes are made both fixed and portable and are worked by hand or power.

Balanced Armature.—An armature so evenly built up about its axis as to run without jar or vibration.

Balanced Circuit.—An electric circuit so adjusted with respect to neighboring circuits as to escape the influence of mutual induction.

Balanced Load.—A load which is borne in equal proportions by two or more dynamos.

Balanced Magnetic Circuits.—Magnetic circuits in a dynamo armature having the flux generated in the magnetic field evenly distributed throughout the coils.

Balanced Metallic Circuit.—A metallic circuit having both sides alike with regard to electrical properties.

Balanced Polyphase System.—A polyphase system of electric distribution having current and phase symmetrically distributed through all its branches; *balanced multiphase.*

Balanced Reaction Coil.—A choking coil in connection with an alternating current transformer which preserves the current in the secondary circuit uniform under changing loads.

Balanced Relay.—A relay having its armature passive when equal currents traverse both coils in opposite directions around the core.

Balanced Resistance.—An unknown resistance which has been balanced by the known resistances of a Wheatstone bridge.

Balanced System.—1. A system of electric transmission constructed with such precision as not to be liable to induction disturbances from other circuits.

2. In a three wire system of electric lighting, a condition existing when the number of lamps on the two sides of the system are equal.

Balance Galvanometer.—A galvanometer for indicating when the pressure developed by a dynamo is equal to the bus bar pressure, when a fresh dynamo is to be switched into a circuit for the purpose of increasing the load.

Balance Indicator.—1. Any indicator to show the occurrence of an electric balance.

2. In the three wire system, an instrument to show when a balance of the potentials of the two sides of the system is reached.

Balance of Induction in Cable.—The result of counteracting induction effects in a cable by certain opposite effects.

Balance of Telegraphic Circuit.—In duplex or quadruplex telegraphy, a "balance" preserved between the main line and the artificial line.

Balance Photometer.—A photometer which measures the intensity of light by its action upon iodide of nitrogen.

Balance Wheel.—In machinery, a wheel which imparts regularity to the movements of any engine or machine; a *flywheel.*

Balance Wire.—The neutral or central conductor of a three wire system of electrical distribution; *the neutral wire.*

Balancing.—In mechanics, the removal of irregularities in weight from those portions of a revolving body where it is in excess, in order to equalize the strains upon it due to momentum and centrifugal force. Hence, rapidly revolving pulleys and wheels are, where possible, turned all over. When that is not practicable they are hung on a free spindle and the weight of the heaviest sides reduced in succession by drilling out holes, or in other ways removing superfluous metal. Such a pulley or wheel is then said to be balanced. Another mode of balancing is when a balance weight is attached to a driving or a flywheel to counter-balance the mass of a crank, or an eccentric sheave, or similar projecting portion on the axle. All good mechanisms and rapidly revolving parts are thus balanced.

Balancing Method.—In measuring resistances by the Wheatstone bridge, a method of balancing the four resistances of the arms so that a sensitive galvanometer, properly connected in the circuit, will show no deflection.

Balancing of Telegraph Line.—In duplex and quadruplex telegraphy, a balance of resistance and static capacity maintained between the main line and the artificial line, so that the action of the home transmitting instruments does not operate the home relays.

Balancing Resistance.—A resistance for the purpose of balancing one dynamo with another running in parallel with it.

Balancing Set.—A pair of small dynamos coupled together and introduced between the mains, for the purpose of changing from a two wire to a three wire system of electric distribution.

Balancing Thermopile.—A thermo-electric battery so arranged as to measure very small differences in the temperatures of two bodies. Also called, *differential thermopile.*

Balancing Transformer.—A synchronizer consisting of two transformers having their primaries connected, one to a loaded and the other to an idle dynamo, their secondaries connected in series through a lamp; when the secondaries are cross connected the lamp burns brilliantly, when in straight series the lamp is dark at synchronism.

Balata.—An elastic gum, obtained from a tree which grows in Venezuela, the Guianas and the West Indies. It resembles india-rubber and gutta-percha, having the elasticity of the former and the ductility of the latter. It is largely used as an insulating medium in electrical practice.

Ball and Socket Joint.—A joint in which a ball or spherical object is placed within a socket recessed to fit it, thus permitting free motion in any direction within certain limits. A ball and socket mounting is usually applied to shafting supports to make them self-adjusting.

Ballast.— In the Nernst lamp, a resistance consisting of iron wire in a glass tube containing nitrogen in series with the glower. The resistance of the ballast increases with the temperature while that of the glower diminishes, so that a balance results between them, and the current becomes constant.

Ball Bearing.—A bearing whose journal works upon rings of balls, which roll easily in their grooves or *races*. Friction upon a series of points is thus substituted for that upon a surface, thereby eliminating a considerable amount of the total friction. The balls are made of hard cast iron or steel. Fins and spurs are removed on an emery wheel, then they are ground to shape within a series of tumbling barrels, the first barrel being filled with balls and *slag*, the next with balls and *emery*, the last with balls, *flour emery* and *leather clippings*.

Ballistic Curve.—The curve actually followed by a projectile in its course through the air.

Ballistic Galvanometer.—A sensitive galvanometer which is not "dead-beat," employed to measure the capacity of telegraph or telephone conductors. When a sudden charge is passed through the instrument the needle swings off in proportion to the force of the discharge.

Ballistic Method.—The measurement of a magnetic flux by the use of a ballistic galvanometer.

Ballistic Pendulum.—An early apparatus for measuring the velocity of projectiles; it consists of a heavy pendulum which is swung, or thrown, by the force of a projectile striking against it.

Ballistics.—The science that deals with the path, velocity and impact of projectiles.

Ball Joint.—A universal joint, sometimes employed in piping. The globular end is retained in its hollow seating with a gland screwed over it.

Ball Lightning.—A kind of lightning in the form of balls of fire which move along slowly and then explode with a loud report. It is of rare occurrence.

Balloon Buoy.—A balloon shaped buoy employed in submarine cable operations.

Balloon Signaling.—A system of military signaling by means of telephone connections with a balloon raised to overlook the movements of the enemy.

Bamboo.—The stalk of a giant grass, of which there are many varieties. The bamboo is used for very many purposes, particularly in the East, where it furnishes material for building and for a large variety of useful articles.

Bamboo Filament.—An early form of incandescent lamp filament devised by Edison. It consists of fiber derived from the bamboo and subjected to the carbonizing process.

Banca Tin.—Tin ore from Malacca and Banca; it is the purest ore known and is valued accordingly. It is sold in blocks weighing from 40 to 120 lbs. each.

Band Arc Lamp.—An arc lamp in which the upper carbon is fed down by the action of a copper strip or band connected with the carbon holder.

Band Spectrum.—A spectrum of light, in which the colors, instead of shading into one another, as in a *continuous* spectrum, are broken into broad lines, or bands.

Banjo.—In pole line construction, a contrivance for tightening a wire, consisting of a drum mounted upon a kite shaped board.

Banked Battery.—1. A battery which distributes electricity to several separate circuits.

2. A battery having its cells connected in parallel.

Banking Fires.—A practice adopted to check combustion, where steam has to be maintained in readiness in boilers; as, on a steamship. The fires are raked to the

front of the furnace, and smothered with ashes or slack coal, the suppressed combustion of the interior affording sufficient heat to maintain the heat of the boilers while no steam is being used.

Banking Transformers.—The process of bringing together a group of transformers to form a "bank."

Bank of Lamps.—A cluster of electric lamps mounted upon a single base, used to indicate the voltage of a dynamo which is about to be switched into a circuit; also called, *battery of lamps.*

Bank of Transformers.—A number of transformers grouped together for convenience in changing the pressure.

B. A. Ohm.—The standard ohm of the British Association. It is the resistance of a column of pure mercury one square millimeter in cross section, 104.9 centimeters long, and at a temperature of 0° Centigrade.

Barad.—A unit of pressure, equal to one dyne per square centimeter.

Bar Armature.—An armature having conductors of copper strips or bars, as distinguished from a wire wound armature.

Barb Bolt.—In machinery, one having jagged edges to prevent retraction after driving; *a rag bolt.*

Bare Carbons.—Carbons for arc lights or battery cells, consisting of the exposed substance without a metal coating of any kind.

Barff's Process.—A process employed to protect iron from rust. The iron is first heated to redness, and steam is then passed over it. The steam being decomposed by the iron, oxygen is liberated which immediately attacks the iron and forms a protective coating of magnetic or black oxide.

Bar Iron.—A shop term for wrought iron when rolled into long bars of plain sections or *round, flat, square,* etc.

Bar Magnet.—A magnet in the form of a short straight bar.

Barograph.—A recording barometer, in which the motions of an aneroid are conducted by linkwork to a tracing point, moving it over a traveling roll of graduated paper, thus registering variations in atmospheric pressure.

Barometer.—An instrument for measuring the pressure of the atmosphere. The mercurial barometer is a glass tube 33 to 34 inches high, sealed at the top, filled with pure mercury and inverted in an open cup of mercury. A graduated scale on the instrument permits observations of the fluctuations in the height of the mercurial column, which is highest when the atmosphere is dry, weighing more then than when saturated with aqueous vapor, which is lighter than air. The height of barometric measurement is about 30 inches.

Barometric Column.—The column of mercury supported in a barometer tube by the pressure of the atmosphere.

Barometric Gradient.—In meteorology, the difference of barometric pressure in a given distance measured between two *isobars.*

Barrel of Jack.—The cylinder of a tubular jack in a telephone switchboard, into which the connecting plug is inserted.

Barrel Winding.—A form of direct current armature winding in which the end connectors of the form wound coils are carried out in line with the winding surface of the armature, thereby giving the armature greater length and exposing the connectors to the cooling influence of the air.

Barring.—In steam engineering, the turning round of an engine flywheel with an iron bar, to get the engine over the dead center in readiness to start. Points of leverage are afforded by fixed pins, suitably placed adjacent, and a few holes are drilled in the flywheel to take the point of the bar. Also the initial turning of a large engine by a smaller engine.

Barring Engine.—A small auxiliary engine used to revolve large stationary engines, either to turn them in the proper position for starting, or to move them during overhaul.

Barrow Reel.—A reel employed in pole line construction for carrying a coil of wire upon a *wire barrow.*

Bars of Commutators.—A part of the commutator of a motor or generator, consisting of a series of metal segments made of copper or brass and insulated from one another.

Bar Windings.—Copper strips, or bars, used instead of wire windings as conductors upon an armature.

Base.—1. The bottom of anything considered as its support, or the part of a thing on which it stands or rests; as, the *base* of a column.
2. In chemistry, a body which can combine with an acid to form a salt. Bases are classified as follows: (1) Oxides, such as quicklime or magnesia; (2) hydrates, as caustic soda, or slaked lime; (3) a class represented by ammonia and its derivatives. Certain bases are caustic, possess an alkaline or astringent taste, and turn red litmus paper blue, these being more popularly known as *alkalis*.

Base Plate.—A heavy iron piece used as a foundation for a machine; specifically, a casting, provided with horizontal adjusting wedges, which is used to support pillow-blocks when mounted in wall boxes or on pedestals.

Basis Metal.—In electroplating, the metal upon which another metal is to be deposited.

Bat Bolt.—In machinery, a bolt barbed or jagged at its butt or tang, to retain it within an object cast, or solidified about it.

Batch Working.—A method of despatching telegraph messages by sending them in "batches" in one direction, and a number in turn in the other direction, as opposed to *up and down working*.

Bath.—1. Any receptacle containing a liquid, fluid or molten metal, into which articles are dipped in manufacturing processes, to clean their surfaces, or to cover them with a coating of the fluid body; as, in *tinning*.
2. In electroplating, a vessel containing an acid solution of some metal, in which articles are immersed for the purpose of covering them with the coat of the metal in solution, by *electro deposition*.
3. A bath fitted with connections and electrodes for treating patients with electricity; an electro-therapeutic bath.

Battening Rule.—In building construction, a rule or *templet* by which the batter or slope of a retaining or breast wall is regulated while building.

Battery.—A number of primary or storage cells, condensers, or dynamos grouped together as a single source of electricity. A term commonly, though incorrectly, applied to a single cell.

Battery Gauge.—A simple handy form of galvanometer for ordinary use in testing electric batteries.

Battery Jar.—The vessel which holds the solution and electrodes, forming one of the cells of an electric battery.

Battery Lamp.—An incandescent lamp which is maintained by the current supplied by a small series connected battery.

Battery Meter.—A small instrument about the same size and shape as a watch for testing the voltage and amperage of batteries. As usually constructed its range will cover two cells of a primary or one cell of a storage battery.

Battery Motor.—A motor capable of being driven by the electro-motive force generated by an electric battery.

Battery Mud.—A muddy sediment, consisting of metallic copper, deposited by the zinc in a gravity cell after wasteful action.

Battery of Alternators.—Several alternating current dynamos so joined as to serve as a single electric source.

Battery of Generators.—Several generators connected as a single electric source.

Battery of Lamps.—A panel containing a group of lamps used for obtaining a load, etc.

Battery Protector.—An automatic device for opening the circuit when a battery is accidentally grounded.

Battery Railway System.—A system of electric traction by storage batteries carried on the cars; *storage battery traction*.

Battery Solution.—The solution which acts chemically upon the metallic plates in a battery cell, and thus generates the electric current; the *electrolyte*.

Battery Stand.—An insulated support for an electric battery.

Battery Switch.—A device employed in a storage battery installation for cutting cells in or out of circuit in order to maintain a constant voltage; *an end cell switch*.

Battery Syringe.—A syringe for the purpose of handling the electrolytic solution either when filling or emptying a battery cell.

Battery Transformer.—A transformer designed to increase the pressure of a battery current.

Battery Zincs.—The negative (—) electrodes of a primary battery.

B. A. U.—Abbreviation for British Association unit.

Bauxite.—A mineral from which aluminum is derived. The ore, which occurs in the southern states of the U. S., is first treated by chemical processes to remove the impurities and reduce it to aluminum oxide, commonly known as alumina. Alumina is then acted upon by electrolysis with high temperature, and pure metallic aluminum is deposited.

Bay Bolt.—A bolt with a barbed shank.

Bead Areometer.—A variety of areometer or hydrometer containing beads of different specific gravities for the purpose of readily ascertaining the density of the solution in a storage battery cell; *a bead hydrometer*.

Beaded Cable.—A cable suitable for high tension work having an outside protection of porcelain beads.

Beaded Tubes.—The ends of boiler tubes, after being expanded are beaded or rounded with a beading tool, just as rivet heads are finished with a die or snap.

Bead Lightning.—An unusual form of lightning flash having the appearance of a broken line, suggesting a resemblance to a string of beads.

Beaker.—A cylindrical glass vessel, having a wide flanged foot and a lip for pouring. Much used for containing or measuring liquids in a laboratory, being generally graduated to mark its contents in cubic centimeters.

Bearing.—1. A support upon which anything rests.

2. The area or length of the sustained piece which rests upon the support or is in contact with it.

3. A support for a revolving shaft or the like; the *bearing* is composed of various parts; the *journals* or bearings of the shaft; the *brass box* or *step* in which the journal rotates; the *block, pedestal* or *frame* supporting and enclosing the brass; and the *keep* or *cap* which secures the whole together by aid of bolts or studs.

Bearing Pressure.—1. In mechanics, the action of force of bearing or resting; as, the pressure of a beam on a wall.

2. The pressure of a revolving shaft upon its bearing; usually measured in pounds per square inch of projected area.

Bearing Surface.—1. The projected area of the surface upon which a shaft rotates.

2. The surfaces of bearing parts which are in mutual contact. The larger the total bearing surface, the less the amount of friction per unit of surface, since pressure is then distributed over a larger area.

Beaumé's Hydrometer.—Two different instruments are known by this name, one for liquids heavier than water, and the other, more generally used, for those liquids lighter than water. In the first, the hydrometer floats at 0° in pure water, and the stem is usually graduated up to 66° which equals the specific gravity of sulphuric acid. With the second, the stem shows 10° in pure water, and is graduated up to 90°. To avoid long stems, instruments of both types are made to cover only a small range of degrees, one hydrometer being employed for use from 10° to 40°, and another to show from 40° to 70°.

Becket.—1. A rope grommet used as a handle for lifting articles.

2. A wooden cleat or hook for securing lines.

3. A loop or cleat of any material through which a fastening may be passed.

4. A short length of line with an eye at one end and a knot at the other to secure articles temporarily together.

5. A loop at the lower end of a wooden block, to which the standing part of the fall is made fast.

Becquerel, Alexandre Edmond.—Born 1820, died 1891. A French physicist, son of A. C. Becquerel, distinguished for his investigations on electric light, phosphorescence, fluorescence, etc.

Becquerel, Antoine César.—Born 1788, died 1878. A French physicist distinguished for his investigations in electricity and electro-chemistry.

Becquerel, Antoine Henri.—Born 1852, died 1908. A French scientist, son of A. E. Becquerel. He was the discoverer (1896) of the emission from luminous

bodies of invisible penetrating radiations, now known as Becquerel rays, thereby laying the foundation of the science of radio-activity. In 1900, the Royal Society of London awarded him the Rumford Medal, and in 1903 he was one of the recipients of the Nobel Prize.

Becquerel Rays.—The radiation discovered by A. E. Becquerel to be a property of the metal uranium, due neither to phosphorescence nor to absorption of sunlight, but inherent in the metal itself as a new property, now known as *radio-activity*.

Bedding Brasses.—The operation of adjusting the journals of a shaft and its bearings to each other. After the machine work has been completed as accurately as possible, the shaft is smeared with red marking, placed in its bearings and rotated; when taken apart the points in contact have displaced the marking, and these high places are reduced with scrapers until, after repeated trials, both surfaces present a uniform appearance.

Bed Plate.—A casting forming the foundation of a dynamo, or other machine, and so designed as to give the proper support to the shaft bearings and other parts resting upon it.

Beg, or Bega.—A prefix often used with a physical unit to designate a quantity a billion times as great.

Begadyne.—A force equal to *one billion dynes*.

Beg Erg.—An amount of work equal to *one billion ergs*.

Beg Ohm.—A resistance equal to *one billion ohms*.

Bell.—An electric device for vibrating a hammer so that it beats against a bell. It operates by an electro-magnet which attracts an armature or piece of soft iron forming part of the hammer lever, the attraction ceasing when the circuit is broken by the *contact breaker*, the hammer being drawn back to its original position by a spring whereby the circuit is closed and the operation repeated.

Bell, Alexander Graham.—Born 1847. An American inventor and experimenter, distinguished for his invention of the telephone. Though born in Scotland, he came to America, in 1870, becoming professor of vocal physiology in Boston University in 1872. His experiments on sound transmission led to the invention of the speaking telephone for which he obtained a patent Feb. 14, 1876. His claims being disputed by other inventors, notably Elisha Gray, he carried the matter to the Supreme Court of the U. S. which sustained his rights to the invention, and he is now given credit for being the first to put the principles of telephony into practical application. He also invented the photophone (1880) and the gramophone, and has been active in scientific investigations in various other fields.

Bell and Spigot Joint.—The customary method of jointing cast iron gas or water pipes. Spun yarn is first stemmed into the bottom of the annulus formed by the *spigot* of one length and the *bell* of the next. A mould of fire clay is placed over the end of the pipe and the remainder of the groove poured full of molten lead. When cool, the fire clay is removed and the lead caulked around the joint, beginning at the bottom.

Bell Armature.—A bar of soft iron to which the hammer lever of an electric bell is attached; it is held in position between the electro-magnet and contact breaker pin by a flat spring attached to the frame of the bell.

Bell Box.—A box for holding a telephone bell.

Bell Hanger's Joint.—A method of connecting the ends of telegraph or telephone wires by a simple loop.

Bell Metal.—A bronze containing about 80% copper and 20% tin, zinc being added for large church bells, while chimes are cast from 87½% copper and 12½% tin.

Bell Pull, Electric.—A mechanism for ringing an electric bell by the action of a pull.

Bell Shaped Magnet.—A peculiar form of horseshoe magnet, shaped like a split cylinder, for use in certain varieties of galvanometers.

Bell Switch.—A switch for cutting a bell out of circuit.

Belt.—A band of leather or other flexible substance, passing around two wheels, communicating motion from one to the other. Belts can be made of any flexible material, cloth, rubber, leather, and can be run in any way, at any angle, of any length, and any speed. The working adhesion of a belt to the pulley will be in proportion both to the number of square inches of belt contact with the surface of the smaller pulley, and also to the arc of the circumference of the pulley embraced by the belt. This adhesion forms the basis of correct calculation in ascertaining the width of belt necessary to transmit a given horse power.

Belt Circuit.—A circuit for electric lighting connected in series, and forming an extended loop instead of running in two neighboring parallel lines.

Belt Clamp.—A device consisting of a *stretching frame*, the two ends of which are coupled by screwed bars; used for pulling the two ends of a belt together with the proper tension, when *lacing* or joining the ends.

Belt Dressing.—A paste applied as a preservative to leather driving belts, rendering them soft and pliable, thus securing better adhesion and improved driving power. The best compounds are a mixture of fish and animal oils; say, cod liver oil and tallow, melted together and incorporated while warm, cooling to an ointment. This is worked into both sides of the belt with a square brush, such as is used for polishing shoes. Boiled linseed oil is said to be the best dressing for cotton belting.

Belt Drive.—The transmission of power from a prime mover by means of belts and pulleys, as distinguished from *direct drive*.

Belt Driven Dynamo.—A dynamo driven by a belt connected with the motive power, as distinguished from one that is *direct driven*.

Belt Fastener.—A device or contrivance for uniting the ends of belting, many diverse types being used as a substitute for leather laces. *Belt hooks* are curved pieces of brass or copper wire, with each end hooked towards the middle; the fastener is placed inside the belt, a hook passed through either end of the latter, and the points of the hooks flattened down on the outside, to secure the joint. *Belt studs* are made of brass and resemble the letter I. The two belt ends are opposed to each other and slitted back to back by a special cutter; the stud is inserted edgewise through both pieces, turned half around when in place, thus completing the fastening. Other fasteners consist of metallic plates furnished with numerous vertical teeth, these are driven through the belt and clinched over the plate, forming a sort of butt strap.

Belt Lacing.—Thongs of soft oil tanned leather used to fasten driving belts, being threaded from hole to hole in either end of the same.

Belt of Current.—The electric current produced by an armature considered as making one complete revolution, or *belt*, around the armature.

Belt Stretcher.—In millwrighting, a mechanism employed to stretch new leather belting. But belts are stretched very commonly by being suspended in a loop from above and loaded with weights. All new belts must be stretched before using, otherwise they will soon have to be taken up, shortened and relaced.

Belt Tension.—The ultimate strength of leather belts varies from 3,000 to 5,000 lbs. per square inch. But at the laced joints the strength is only 30% of those values, or from 900 to 1500 lbs. per square inch. The *working tension* should not exceed about 300 lbs. a square inch. A good rule is 20 lbs. per inch of width for each $\frac{1}{16}$ inch in thickness of the belt. The tensile strain is found by multiplying the number of the H. P. to be transmitted by 33,000 and dividing the product by the velocity of the rim of the pulley in feet per minute. This represents the strain in pounds upon the driving side independently of the initial tension producing adhesion between the pulley and the belt. This initial tension should be sufficient in amount to prevent slipping on either of the pulleys at the moment of starting.

Bending Moment.—In mechanics, tendency or measure of tendency to produce *bending*.

Bending Stress.—In physics, a force acting upon some member of a structure tending to deform it by bending or flexure, the effect of this force causes bending *strain* on the fibers of the material of which the part is composed.

Berrite.—An impregnating gum employed for insulating cloth and paper. It is brittle, but has high disruptive strength, and is not affected by great heat.

Bessemer Process.—A method of producing mild steel directly from cast iron. The process is carried on in a *converter*, an egg-shaped retort, swinging upon trunnions, through which a powerful current of air is blown. The converter is charged with molten iron from the blast furnace while in a horizontal position, and is swung into the vertical as the blast is applied. The silicon floats as slag on the surface and is removed separately; the oxygen of the air burns away other impurities and combines with the carbon. The *spectroscope* is used to watch the mouth of the converter, to notify when the carbon disappears from the spectrum of the flame; when freed from carbon, the converter is swung through a small arc and a measured quantity of *ferro manganese* or *spiegeleisen* added to insure the right percentage of carbon, the blast being once more applied to effect thorough incorporation. Subsequently the converter is lowered horizontally, and emptied into ladles, whence its contents are cast as *ingots*.

Best Best Iron Wire.—A superior grade of iron wire intermediate in quality between *extra best best* and *best*.

Best Iron Wire.—The poorest grade of iron wire for electrical purposes, so called in distinction from *best best* and *extra best best.*

Beta (β) Rays.—One of the three types of rays emitted by radio-active substances. Beta rays are regarded as negatively charged material particles given off with very great velocity, having moderate penetrating power, comparatively small power to ionize a gas, small effect on a photographic plate, a velocity equal to that of light, in fact they are practically identical with cathode rays except in velocity of motion.

Beton.—A European name for *concrete,* made according to the system of its inventor, M. Coignet.

Betty.—A round iron bar flattened to a chisel like expansion at one end and used for raising heavy weights through a short distance; for pushing cars along a line of rails through a limited distance, and generally for the application of a large leverage for a temporary purpose.

Bevel Gearing.—An arrangement of beveled wheels for the transmission of motion from one shaft to another, almost any angle being included by adaptations of the principle.

Bevel Square.—A square whose blade may be set to any required angle in the *stock* that holds it.

Bias of Relay Tongue.—In duplex telegraphy, a one sided adjustment of the armature or tongue of the polarized relay, such that when no current flows it rests against the nearest pole or the insulated stop.

Bi-carbonate of Lime.—In steam engineering, the principal compound to whose deposition the incrustation of steam boilers and water pipes is due. It is at first held in solution in the water as a bi-carbonate, by the excess of carbonic acid. This excess being driven off by heat, the carbonate of lime remains as a floury or muddy deposit, its precise condition varying with the nature of the salts with which it is usually accompanied. In the presence of heat it hardens and forms an injurious scale.

Bi-chromate Cell.—A single fluid cell consisting of two plates of gas retort carbon as the negative element, and between them a single plate of zinc; the exciting liquid is composed of a saturated solution of potassium bi-chromate in water and strong sulphuric acid; also known as *Poggendorf's cell.*

Bi-chromate of Potash.—Properly, *potassium bi-chromate,* the salt of chromic acid, with the metal potassium. It is a red crystalline solid, soluble in water but insoluble in alcohol, and very poisonous. The bi-chromate is used in analyzing iron, as a reagent in various processes, and in primary batteries.

Bicro.—A prefix often used with a physical unit to designate *one-billionth part* of that unit.

Bicycle Car.—An electric car running upon a single rail, and kept erect by the aid of a guide rail.

Bicycle Lamp, Electric.—A bicycle lamp supplied with a small battery capable of sustaining an incandescent light.

Bifilar Control of Galvanometer Needle.—A method of controlling the needle of a galvanometer so that it is restored to its original position, after deflection, by the action of the two threads in bifilar suspension.

Bifilar Suspension.—Suspension by two equally long threads, as a means of measuring forces of rotation.

Bifilar Winding.—A method of winding resistance coils, in which the wire is doubled before it is laid on, so as to overcome self induction.

Bight.—The loop in a cable or wire.

Billet.—A short rectangular bar of mild steel, wrought iron or piled scrap, measuring about 18 inches long by 3 inches square. *Steel billets* are produced for rolling into plates for tinning; others are made for manufacturing small sections of finished iron or steel, or for smiths' use.

Billion.—According to the French and American method of numeration, a *thousand millions* or 1,000,000,000; according to the English numeration a *million millions* or 1,000,000,000,000.

Bimetallic Accumulator.—A secondary or storage cell containing two electrodes of different metals.

Bimetallic Helix.—A coil composed of wires of two different metals which are so joined that the spiral is acted on by the unequal expansion or contraction of the two wires.

Bimetallic Thermometer.—A thermometer composed of a bar of two metals having different rates of expansion, brazed together or built into a helix or spiral, which, under torsion brought about by changes of temperature, moves an index upon a scale.

Bimetallic Thermostat.—A thermostat for opening or closing an electric circuit by the action of the temperature upon a spring or scale of two different metals welded together.

Bimetallic Wire.—A steel wire with an external coating of copper. It can be used for long spans on account of the high tensile strength of the steel. Also called composite wire.

Binary Compound.—In chemistry, a compound of two elements or radicals acting as a single element.

Binder Pulley.—A pulley, the sole function of which is to bind or tighten a belt or cord on its driving and driven pulleys, when owing to extension or shrinkage of the belt or cord, the tension becomes variable in amount. The binder pulley is properly made adjustable.

Binding Coils.—Coils of wire wound outside the windings of an armature to hold them firmly in place against the loosening tendency of the centrifugal force of the rotation.

Binding Post.—A metal post furnished with a screw for securing the end of an electric wire. The wire is sometimes inserted in a hole, having a screw tapped in at right angles and screwed down upon the wire. In other types of binding posts, the wire is clamped between two shoulders, one on the post and one on the screw; a flat headed thumb screw having a milled edge, is often used; also, a screw having a slot, so as to be turned by a screw driver.

Binding Wire.—1. The tie wire for fastening a telegraph wire to an insulator.

2. Fine copper or brass wire, about 40 S. W. G., used for wrapping around joints and splices in wire work, and for many other useful purposes.

Binnacle.—A stand or case for a ship's compass, provided with lamps for illuminating the dial and usually located beside the steering wheel.

Bioscopy, Electric.—The application of an electric current to the nerves or muscles of the human body to determine whether or not life is extinct in doubtful cases of apparent death.

Biphase.—A term sometimes used for two phase; as, a *biphase alternating current.*

Bipolar.—Having two magnetic poles; *dipolar.*

Bipolar Armature Winding.—Winding an armature in such a manner as will adapt it for use in a bipolar magnetic field.

Bipolar Dynamo.—An electric generator having a magnetic field produced by two opposite poles.

Bipolar Magnetic Field.—A magnetic field created between two magnetic poles.

Bipolar Receiver.—A form of telephone receiver in which both poles of the electromagnet are presented to the diaphragm in order to strengthen the field; a *double pole* or *two pole receiver.*

Bird Cage.—A laceration of a submarine cable in which the sheathing is torn away and the conductors protrude like a wire cage.

Birmingham Wire Gauge.—Formerly the English standard for wire and sheet metals, but now employed for the latter only. Its numbers run from 0000 to 36, the former equaling 0.454 inch and the latter 0.004 inch. The B. W. G. is now replaced as a standard in Great Britain by the *Imperial Wire Gauge,* legalized in 1884.

Bisecting Scale.—A flat scale in a measuring instrument fully and symmetrically divided on each side of its center line. It is usually graduated for ¼ inch, ½ inch and 1 inch scale.

Bismuth.—A very brittle crystalline metal, of a grayish white color tinged with pink or red. It is a remarkable metal for two properties; its specific gravity decreases under pressure, and it expands on cooling. Various compounds of bismuth with other metals melt at points below that of boiling water, *Wood's metal,* of 4 bismuth, 2 lead, 1 tin, 1 cadmium (all by weight) melts and remains fluid at 142° F. Bismuth is used in many alloys under the name of *expansion metal.*

Bismuth Spiral.—An instrument containing a spiral of bismuth, a conducting metal, for the purpose of measuring intense magnetic fields.

Bi-telephone Receiver.—A form of double telephone receiver to be fitted over the head and applied to both ears of the listener.

Bitite.—A substance used for insulating purposes.

Bitumen.—1. A mineral pitch or *asphalt;* the residue of forms of petroliferous deposits, whose more volatile constituents have evaporated by the processes of nature.

2. A pigment or paint resembling sepia, made by grinding asphalt with a drying oil.

Bivalent.—In chemistry, a term applied to an atom having a valence, or combining capacity of two units; *i. e.*, having a capacity to unite with two atoms of hydrogen. An *ion* is bivalent, or can combine with two hydrogen atoms, if it carry two electric charges.

Black Deposit.—A dark colored sediment that is deposited in the process of electroplating when too strong a current is applied to the bath; also called, *burnt deposit.*

Black Lead.—One of the natural forms of carbon. Used with or without the addition of oil for coating the faces of cast iron chilling moulds, also as a lubricant.

Black Leading Machine.—A machine used in the process of electrotyping for depositing a layer of graphite over the face of the wax impression to render it capable of conducting electricity.

Black Light.—Radiant energy that fails to produce light.

Black Oils.—In lubrication, crude mineral oils of good body which have been subjected to one series of purification only, to remove their mechanical impurities and volatile oils, but which have not been filtered to improve the color. They are used for cylinder lubrication.

Black Red Heat.—That temperature of wrought iron or steel in which the red color is just visible by daylight. It may be roughly taken as corresponding with 1,000 degrees Fahr.

Blake, Francis.—Born 1850. An American astronomer and inventor. From 1866 to 1878 he performed distinguished service for the U. S. Government in connection with the coast survey. After his resignation, he devoted himself to electrical experiments, the chief result of which is the telephone transmitter, known as the Blake transmitter. In this he improved upon fundamental inventions which preceded him, receiving a minor patent in 1881. Greater improvements followed, and the Blake transmitter long remained the prevailing type in U. S. telephone practice.

Blake Transmitter.—A carbon telephone transmitter, until recently almost universally used in the United States. It is based upon the principle that when two pieces of carbon lie loosely together, differences of pressure at the contact causes variations in electrical resistance.

Blank Bolts.—In machinery, the rough forgings of the bolts previous to screwing.

Blank Panel.—A switchboard panel provided to accommodate extra circuits if required.

Blasting, Electric.—The use of electricity for igniting the explosives in blasting; heavy wires are carried from a current source at a distance to a special fuse, in which a fine platinum wire is joined in the circuit. The great resistance of the fine wire causes it to heat when the current flows, and being surrounded by an easily combustible substance to serve as a priming, ignites this and sets fire to the explosive charge.

Blaze.—A stream of gas or vapor emitting light and heat in the process of combustion; a bright flame.

Bleaching, Electric.—A process of bleaching by the action of electrolysis.

Bleeder.—A small cock or valve to draw off water of condensation from a range of piping.

Bleeding.—In steam engineering, the red streaks of rust which *weep* through the scale adhering to the insides of boilers, and which reveal the presence of corrosion in the plates underneath.

Blende.—1. A mineral also called by miners, *mock lead; false galena* and *black jack.* It is a zinc sulphide, but often contains some iron. Its color is usually yellow, brown or black, and its luster resinous.

2. A general term for some minerals, chiefly *metallic sulphides*, which have a somewhat brilliant but non-metallic luster.

Blister Copper.—Fine copper which has been roasted to expel sulphur, and melted, being then cast into slabs preparatory to refining. The gases escaping from the molten copper give it a *blistered* appearance, hence the name; this blister copper is about 96% pure, and its subsequent refining is done by *electrolysis.*

Blister Steel.—Steel made by the first process in the production of carbon or tool steel, by heating wrought iron in intimate contact with charcoal. Its surface is covered with blisters caused by the formation and bursting of vesicles filled with gaseous carbon.

Block.—1. A grooved pulley or sheave encased in a frame or shell, constituting the block proper, which is provided with a hook, eye or strap for attaching it to an object; a block is used to change the direction of motion of a running rope, or as a mechanical power to raise a heavy load. Two or more such sheaves are compounded to change the rate of motion or to exert increased force.

2. In typography, a term including wood cuts, or the hardwood on which they are engraved; zincotypes, electrotypes, etc. 3. In railway signaling, the extent of track between two signal posts or towers, forming one of the sections in the block system for railroads.

Block and Tackle.—A term including the block and the rope wove through it, for hoisting or obtaining a purchase.

Block Section.—A section of railroad track controlled by a set of automatic signals in a block signal system.

Block Signal.—A set of semaphores or lamps automatically operating at the terminals of a block in the block system of railway signaling.

Block System.—A method of railway working, in which the line is subdivided into short sections or blocks, each of which is protected by signals, so arranged that there shall be only one train in a section at a time.

Block Wire.—In a railroad block system, the wire which connects the signal towers.

Blood Stone.—A name often given to *hematite*, the oxide of iron, because of the blood red color which the ore often has in nature.

Bloom.—A mass of wrought iron from the puddling furnace in the form of an oblong block.

Blow.—To melt or fuse, as applied to safety fuses in electrical circuits.

Blow Down.—In steam engineering, the act of letting water out of the bottom of a boiler for shutting up in freezing weather, or *laying off* the boiler for repairs.

Blowing a Fuse.—The melting of a safety fuse by an excessive electric current.

Blowing Off.—Emitting steam at the waste pipe through the safety valves lifting under excessive pressure.

Blowing Point.—The strength of an electric current necessary to "blow," or melt, a fuse.

Blowing Through.—In steam engineering, the sending of a jet of steam through the cylinders and valves, to warm the engine before starting.

Blow Off.—In steam engineering, a term applied to the act of letting out water and steam from a boiler to carry off accumulated mud and scale. Near the bottom of the boiler is a cock value, and opening this the force of the steam drives much of the accumulated scale, etc., with the water and steam out of the boiler.

Blow Off Cock.—A name sometimes given to the blow down cock or valve of a steam boiler.

Blow Out Coil.—In an electric car controller, a coil inserted below the reversing drum for blowing out the electric arc between the contact fingers and the drum strips whenever the circuit is broken.

Blow Out Magnet.—In an electric railway controller, an electro-magnet inserted to blow out an arc that might arise between the contact fingers.

Blow Pipe, Electric.—An air blast effect produced at the tip of a highly electrified pointed conductor by the convective discharge.

Blue Heat.—A low heat, noticeable in iron and steel as it cools down from a red or working heat; it is unsafe to hammer or work these metals at this temperature on account of the distress to the fibers. If anything cannot be bent or flanged at a *red heat*, it should be wrought cold and then annealed.

Blue Pole of Magnet.—A term sometimes used to denote the south pole of a magnet.

Bluestone.—1. A name sometimes given to copper sulphate in crystalline form; also called, *blue vitriol.*

2. A building stone.

Bluestone Gravity Cell.—A gravity voltaic cell containing a copper plate in a solution of copper sulphate at the bottom of the jar, and a zinc plate in a diluted solution of zinc sulphate above it. It is so called from the name "bluestone" or "blue vitriol" by which copper sulphate is popularly called; the Callaud cell.

Board of Trade Unit.—A unit by which electrical supply is measured. An English commercial unit of electrical energy is equal to the amount which is developed or absorbed by a current of 1000 amperes at a pressure of 1 volt during one hour.

Bobbin, Electric.—A spool wound with insulated wire for conducting electricity.

Body Protector.—A short circuiting device for protecting the vital parts of the human body against the passage of an electric current in case of accidental contact.

Boiler.—A vessel in which water is evaporated into steam for the generation of power, for heating purposes, etc. The various types may be classified under two heads: *shell* boilers, in which the water is contained within more or less cylindrical vessels traversed by tubes, through which the flame and heated gases of combustion pass to impart their heat to the water; *tubulous* or *water tube* boilers, in which the water is contained within the tubes, the products of combustion circulating around them on courses determined by suitable *baffles.* The shell boiler is self-contained, or else mounted on brickwork, which contains various flue passages, etc.; the water tube boiler is contained within a suitable casing of brickwork or metal, or both. The chief varieties are the *Belleville, Cornish, Lancashire, Locomotive, Multitubular, Return tube, Water tube,* etc.

Boiler Cleaner, Mechanical.—A device actuated by compressed air, flowing water or a flexible shaft, to clean the interior and exterior tubular surfaces of steam boilers, also those portions inaccessible to ordinary methods. The cleaner usually consists of a boss or head, fitted with revolving scrapers, or else lightly striking hammers to jar off the scale.

Boiler Compound.—A chemical put into a boiler for the purpose of preventing incrustation.

Boiler Covering.—A non-conducting substance used as a clothing for steam boilers, to prevent loss of heat by radiation. It should indicate where a leak occurs, and also be made in *sections,* so as to be removable for repairs to the shell of the boiler, and then easily replaced.

Boiler Feed, Electric.—A mechanism operated by electricity for automatically supplying a boiler with water when the level has fallen to a given point.

Boiler Float.—In steam engineering, a float which rises and falls with the changing height of water in a steam boiler, and so turns off or on the *feed water.*

Boiler Horse Power.—1. A commercial rating based solely upon the heating surface of the boiler, an area of 12 to 15 square feet being taken as the equivalent of one horse power.

2. A unit of power adopted by the judges at the Philadelphia exhibition in 1876, known as the *Centennial Standard:* it equals the evaporation of 30 lbs. feed water per hour, from a feed temperature of 100° F., to steam of 70 lbs. gauge pressure. This is equivalent to 33,305 B. T. U. per hour, or the evaporation of 34½ lbs. of water from and at 212° Fahr.

Boiler Inspection.—Official examination of the internal and external surfaces, braces, etc., of a boiler, at stated intervals, either by government surveyors, or those appointed by insurance corporations.

Boiler Mountings.—A collective name for those attachments to a boiler, necessary for its proper use, including *grates, smoke-boxes, uptakes, damper, funnels, casings* and the like, as well as those parts which are more commonly termed *fittings* by the engine room staff; namely, the various *cocks, gauges, valves,* etc. The brass mountings are more properly termed *fittings;* in some localities they are designated as *trimmings.*

Boiler Plate.—A term formerly used to denote superior qualities or brands of wrought *iron,* suitable for making into the shells or drums of steam boilers. Lowmoor or *equal quality* is alone used for such parts as require an excessive amount of working in the fire. Steel plates are now used instead, being obtainable in almost any size, thus reducing the number of seams and the consequent amount of riveting. A usual specification for the steel is 60,000 to 72,000 lbs. tensile strength, with an elongation of from 18 to 20%. Steel rivets are generally used, although the practice of some firms is to employ wrought iron rivets in conjunction with softer plates, possessing an ultimate strength of 55,000 to 60,000 lbs. per square inch.

Boiler Pressure, Safe Working.—The highest pressure considered safe to carry on a steam boiler consistent with the factor of safety employed in its design.

Boiler Stays.—A rod, plate or the like firmly joining two parts, as plates or sheets, at an angle to each other, or holding them at a fixed distance. The long through stays within the steam space are denominated *bar stays;* these screwed through two plates are *screwed stays* or *stay bolts:* those flattened out at one end for riveting to a plate, are termed *palm stays.* A stay is sometimes termed a *brace.* Other types are named *crowfoot brace, sling stay,* etc. Boiler stays are generally specified not to have been welded or worked in the fire. The first condition is universal, an exception to the second being that certain navies and railroads have the screwed ends of their boiler stays jumped up under a hydraulic press, to secure a plus thread.

Boiler Testing.—In steam engineering, there are two ways of testing a steam boiler; in testing by *steam,* the conditions of strain are the same as those under which the boiler is worked. Another method of testing is to pump cold water into the boiler until the desired pressure is reached. The distortions or defects of joints are then noticed; if a boiler leaks under pressure, the leaky joints should be marked and calked when the pressure is off.

Boiling of Secondary.—A term used to denote the *gassing* from the plates of a storage battery. The action is due to too great strength of the charging current.

Boiling Point.—The temperature at which a liquid begins to boil. The boiling point varies with the pressure and with the nature of the fluid; thus, the boiling point of ether is 95° F., of water 212° F., under pressure of one atmosphere.

Bole.—A proposed C. G. S. unit of *momentum,* equal to one gram-kine, or one gram moving with a velocity of one centimeter per second.

Bolometer.—An instrument of great sensitiveness, consisting essentially of a Wheatstone bridge having two strips of blackened platinum foil inserted in the arms, for measuring minute quantities of heat energy by the changes of electrical resistance produced in a metallic conductor by variations of temperature; a thermal balance.

Bolt.—A discharge of lightning; as, a flash of lightning.

Bombardment.—1. In an exhausted vessel the forcible projection of the residual gaseous molecules from the negative electrode, on heating or on the passage of an electric discharge.

2. In physics, the very rapid striking of the molecules of a gas against each other or against the walls of a containing vessel.

Bombardment Incandescent Lamp.—A lamp in which incandescence is produced by the *molecular bombardment* resulting from the discharge of electricity through a highly rarefied space.

Bond.—The method of laying brickwork or masonry so that the work becomes firm and stable, by proper use of *stretchers* and *headers,* and care that a vertical joint is covered by a solid center above or below. *English bond* consists of alternate courses of stretchers and headers; *Flemish bond* of stretchers and headers laid alternately in the same course, care being taken to break joint with the courses above and below; *stretcher bond* is used for half-brick walls or partitions, a header course of bats or half bricks being laid every few courses of stretchers, the same bond is used on nine and fourteen inch walls in cheap work, but if a substantial job is required there should be no more than three courses of stretchers for one of headers, and the breaking of joints must be carefully watched.

Bonded Rails.—Rails in a trolley street railway system so connected at their joints by *bonds* (*i. e.,* short pieces of copper wire riveted into the adjoining ends) as to preserve the conducting capacity of the tracks.

Bonding Resistance of Rail.—In a street railway system, the resistance to the electric circuit offered at the points where the rails are connected by bonds.

Bonding Stone.—A stone running through a masonry wall from one face to another, to bind it together.

Bond Tester.—In electric traction, a device for testing the electric conductivity of rail bonds.

Bond Timber.—A longitudinal timber placed in the wall of a building to tie the brickwork together and support superincumbent weight. A *wall plate* or *lintel* is often understood by the same general term.

Bonnet.—1. A cap put over a pile to prevent splintering or damage when driving.

2. A cover, raised in the middle, as those used to guide and enclose the tail end of a steam engine valve spindle, or the drum-shaped covers of a piston valve casing.

3. The hood or metallic cover over the motor, etc., in an automobile.

4. The cover over a pump valve box, or of a slide valve casing.
5. A roof or protection over the top of a cage to shield miners should anything fall down the shaft.

Bony Current.—An electric current between two parts of a bone of a newly killed animal, due to a difference of potential existing between them.

Booster.—A supplementary dynamo inserted in a system at a point where it is necessary to raise the E. M. F. above the normal pressure, or to maintain the required E. M. F. under varying of loads; *an equalizing dynamo; far leading dynamo.*

Boreal Pole.—That pole of a magnet which points southward.

Boring, Electric.—The process of drilling holes by the heat of an electric arc.

Bot.—A term used to denote the English Board of Trade unit of electrical supply.

Bougie Decimale.—The standard French candle, having a value nearly equal to the British standard candle, and equivalent to $\frac{1}{20}$ of the platinum or Violle standard; the *pyr.*

Bougie Meter.—A French unit of illumination; it is the light of the standard French candle at a distance of one meter.

Bound Charge.—An electric charge existing on one of two conductors between which is placed a medium which admits of electro-static induction.

Bound Electrification.—The condition of a charge of electricity on the surface of a conductor when it is attracted by the presence of a neighboring charge of the opposite kind.

Bourdon's Gauge.—The commonest intrument for measuring the pressure of steam, water, air or other fluid. Its essential part is a metal tube of a flattened oval section, which is bent to a curve, the free end being closed, the fixed end open to the pressure. The pressure tends to *straighten the bent tube,* and its consequent movement is communicated by means of linkage, a toothed sector and a pinion, to the axis of a needle or pointer; this moves around a *graduated dial,* registering the pressure of the fluid.

Bow Gear.—A method of rigging the bow of a cable ship for conveniently handling the cable laying operations.

Bow Trolley.—A form of trolley employed in inter-urban and trunk line electric traction. It consists of a pivoted frame carrying a curved or looped contact piece which provides a sliding surface to rub against the overhead wire. It is controlled by compressed air.

Box Bridge.—A commercial form of Wheatstone electric bridge in which the resistance coils and accessories are contained in a box provided with necessary plugs and connections; *a box balance.*

Boxing the Compass.—Repeating in succession the names of all the 32 points or rhumbs of the mariner's compass in their exact order.

Box Metal.—In steam engineering, a term sometimes applied to the metal used for bearings; it may be gun metal or a white metal. One recipe gives copper 32, tin 5; another gives zinc 75, tin 18, lead 4-5, antimony, 2-5.

Box Nut.—In machinery, a nut made for the covering and protection of the end of a bolt. It is similar to an ordinary nut, with the addition thereto of a dome shaped closed end. The screwed part is also terminated internally in a circular recess larger in diameter than the deepest portion of the vee of the thread in order that the cutting tap shall clear itself.

Box Relay.—A form of telegraphic relay for use in special cases, having a wooden box set over the coils in order to reinforce the sound of the signals so that they may be clearly audible; *a telegraphic box sounder.*

Box Spanner.—A socket wrench or T-spanner; having a socket to fit the nut, and a shank vertical to it, either turned by means of a toggle or by the T-handle. Used for turning nuts sunk in a recess below the surface of the piece.

Boyle's Law.—At *constant temperature,* the pressure of a gas varies proportionately to its volume, in an inverse ratio. Thus, if the supply be cut off at half-stroke, the final pressure is half of the initial, assuming no change in temperature. While this is strictly true of perfect gases alone, it is only approximately correct for imperfect gases, such as steam.

Bracket Arm.—In overhead line construction, a pole cross arm stiffened by a bracket support.

Bracket Arm Hanger.—An insulating device for supporting a trolley wire from the end of a bracket arm, consisting of a metal hood carrying a steel bolt embedded in insulating material, for screwing into the boss of the suspension ear.

Bracket Pole.—In overhead line construction, a pole carrying one or more brackets for supporting the wires.

Bracket Suspension Ear.—A suspension ear for a trolley wire attached to a bracket arm hanger.

Bracket Telephone.—A telephone transmitter mounted upon a hinged arm to permit adjustment to the height of the user; *an adjustable telephone arm.*

Braided Wire.—An electric conductor protected by an interwoven insulating covering.

Brake.—1. A contrivance for checking or controlling the speed of a vehicle or machine by means of friction applied to a drum, or wheel; the friction is applied either by means of a band or by pressure on a shoe.

2. A contrivance for measuring the useful effort of a *prime mover* by the substitution of measurable friction for the external load. It consists essentially of a band, usually of steel, shod with wooden blocks, which encircles a flywheel or pulley, the friction of the brake sustaining an arm or lever, to the ends of which either weights or a steelyard are attached.

3. A device consisting of a shoe which is made to bear on the circumference of a wheel by the attraction of an electro-magnet.

Brake Arm.—An arm attached to a brake shoe by means of which the brake is *set;* as, against a trolley car wheel.

Brake Band.—The strap or band of a brake which encircles the drum or pulley, either made of iron alone or of iron faced with leather, wood blocks, etc.

Brake Disc.—A disc shaped electro-magnet sometimes used in the brake of an electric car.

Brake Horse Power.—The useful horse power supplied by an engine as ascertained by the application of a brake, or *absorption dynamometer*. The excess of the indicated horse power over that given by the brake, represents the power required to move the engine itself, and is generally spoken of as internal load or friction.

Brake Shoe.—A heavy block of metal having a curved face so as to fit the rim of a trolley car wheel, etc., which, when the brake is applied, is forced against the wheel to stop its revolution by the friction of the contact.

Branch.—1. An electrical conductor which branches off from the principal conductor.

2. A main conductor which is tapped for the distribution of the current in a parallel system.

Branch Block.—A block of porcelain in which grooves and recesses are cut for conveniently connecting branch wires to a main; allowing, also, for the insertion of safety fuses in the connections.

Branch Box.—A box for holding a branch block.

Branch Circuits.—1. Circuits connected in parallel.

2. Extra circuits supplied where the current of a circuit branches off.

Branch Conductor.—1. A conductor forming a part of a parallel circuit.

2. A subordinate wire leading from a main conductor.

Branch Coupling Box.—A coupling box for the ready connection of the house service of an incandescent system with the mains running under the street.

Branch Current.—In a divided circuit, the current divides, a portion of which flows through each branch, the relative strengths of current in the two branches being proportional to their conductances and inversely proportional to their resistances.

Branch Cut Out.—A safety fuse inserted at the point where a branch wire taps a main.

Branched Magnetic Circuit.—A magnetic circuit which divides into branch circuits for the distribution of the magnetic flow.

Branched Series.—A term used for series multiple connection or method of wiring electric apparatus, in which the parts are grouped in sets *in parallel* and these sets connected *in series.*

Branches.—1. In general, subordinate conductors connected with electric mains.

2. Specifically, in incandescent lighting, the conductors leading from the supply wire.

Branching Boards.—Telephone switchboards employed in the multiple system.

Branching Telephone System.—A system in which the branch multiple terminal or three wire system is used.

Branch of Multiple Circuit.—One of the parts of a circuit system connected in parallel or multiple.

Branch Point of Circuit.—The point in a circuit at which a branch is inserted.

Branch Terminal Multiple Switchboard.—A switchboard for the three wire multiple system in which the jacks for each subscriber are connected in parallel; the three wire multiple switchboard, an arrangement which is rapidly replacing the series multiple board.

Branding, Electric.—A method of branding in which the tool is made red hot by an electric current.

Brass.—A yellow alloy composed of copper and zinc in various proportions. In some grades tin or lead in small amounts is added. Brass is used largely for steam and plumbers' fittings, electrical details, etc.

Brasses.—Bearing steps cast from an alloy of copper and zinc. Generally, all loose bearing pieces or steps are termed *brasses*, though they are most usually made either of *bronze* or *gun metal*, a copper tin alloy, or else of cast iron or steel fitted with recesses filled with a *white* or *anti-friction* metal, composed of tin, zinc, antimony or lead, with occasionally copper.

Brassing.—Electroplating with brass; brass plating.

Brass Plating.—Depositing a layer of brass upon an object by an electric current passing through a brass solution; also called *brassing*.

Brass Tubing.—Used in engineering for cutting off into hand railings, sheathing, distance pieces, etc. Its thickness is given by the wire gauge. The common tube is soldered or brazed; but the best tubes as used for condensers are solid drawn, and usually made of a special alloy.

Brazing.—The art or process of joining metals together. The parts to be united are cleaned, covered with borax as a flux, the *spelter* or brass alloy is placed on the joint, which is heated until the spelter runs in, when it is allowed to set, superfluous brass being afterwards filed off.

Brazing Metal.—An alloy composed of 84% of copper and 16% of zinc. Flanges for copper pipes are cast from this, the per centage of copper having to be high to stand the localized heat of brazing to the tube.

Bread and Butter Cable.—A term describing a variety of submarine cable lightly sheathed with alternate layers of wire and yarn.

Breadth Coefficient of Armature Coil.—The relation of the E. M. F. of an armature coil to the E. M. F. which would be produced in that coil but for the loss due to the breadth of the windings.

Breadth of Coil.—The surface extent occupied by the windings about an armature measured along the length of the armature.

Break.—Any discontinuity in an electric circuit.

Breakdown.—An accident which causes stoppage of the machinery.

Breakdown Switch.—A switch to enable a three wire system of electric distribution to be readily converted into a two wire system by making such connections of the bus bars as to throw one of the dynamos out of the circuit in case of a breakdown.

Break Induced Current.—An extra current in the same direction as the original, induced in a circuit when it is opened or broken; a *direct* induced current.

Breaking Capacity of Switch.—The maximum current strength which a switch can properly interrupt.

Breaking Down of Dielectric.—The weakening effect of persistent electric pressure upon a dielectric whereby charges can finally penetrate its mass.

Breaking Down of Insulation.—The deterioration of an insulation which finally permits the escape of electricity through it.

Breaking Down Point.—In physics, that point in the stressing of a material in which the deformation increases very suddenly. It occurs immediately beyond the elastic limit, and is marked by a well defined and sudden curve in the stress strain diagram.

Breaking In.—In telegraphy, interrupting a despatch in the course of transmission by the attempt of an operator at another point in the line to use the wire at the same time.

Breaking Strain.—The effect, resulting in rupture, occasioned in a material by a stress or load equal to or greater than its *tensile strength.*

Breaking Strength.—In mechanics, the ultimate resistance to rupture of a piece of material of specified size; usually expressed as ability to resist *tensile* stress, but also to be considered with regard to *shearing* or *compressive* stresses.

Breaking the Primary.—Interrupting the primary circuit of a transformer.

Break Joint.—In building and engineering, so arranging the parts of a structure that two or more successive joints may not come in line with each other, a solid part intervening opposite each joint. This adds to the strength of the structure, as in bonding masonry, or prevents leakage or promotes equal wear as in the joints of packing or piston rings.

Break Key.—A key designed for the purpose of breaking a circuit.

Break Shock.—A shock experienced by the human body when undergoing electrical treatment, by the opening, or breaking, of the circuit; *opening shock.*

Break Signal.—In telegraphy, a signal to indicate a space or break in the despatch, as between the address and the message, or the message and the signature.

Breast Plate.—A support for a telephone transmitter adjustable to the breast of an operator.

Breast Telephone Transmitter.—A transmitter supported upon a *breast plate.*

Breast Wheel.—A type of water wheel intermediate between the over shot and under shot. The water strikes it at a point 30° to 45° from its summit, for a *high breast;* at the level of its axle for a *low breast.* The wheel revolves in a curved bed or *breast* of masonry or timber, which has half inch clearance for an iron wheel with masonry, or one inch for wood. This breast terminates about a foot short of the vertical diameter of the wheel. Breast wheels are suitable for falls over six feet, and are more efficient than overshot wheels when there are fluctuations of two feet or more in the level of the head race.

Breath Figures.—Images produced by the moisture of the breath upon the surface of glass on the spots where an electrified object, such as a coin, had previously rested.

Breeze.—A term used to denote air currents from a pointed conductor due to mutual repulsion between the electricity collected on the point of the conductor and the electrified air particles near the point. Also called, *electric wind.*

Breguet's Manipulator.—The sending apparatus of Breguet's *step by step* system of telegraphy.

Brick.—A rectangular block of clay, moulded to regular sizes, and burnt to give it hardness and durability. The usual sizes average 8½x4¼x2. The color of bricks depends upon the amount of ferric oxide in the clay, ranging from white with 1%, through buff and orange, to a deep red with 6%. Common bricks are made from a marly or sandy clay or an artificial marl, termed *malm*, made by mixing chalk with the clay.

Bridge.—1. In civil engineering, a structure erected over a waterway, ravine or road, for the passing of persons, animals, railroads or vehicles.

2. In steam engineering, a lower vertical partition at the back of the grate space of a furnace. The flame in passing the bridge is deflected upward against the bottom of the boiler.

3. An arrangement of resistances combined with a battery and galvanometer devised by Wheatstone for the measurement of electric resistance. It consists essentially of two "proportional arms" of such values that one arm has one, ten, one hundred or one thousand times the resistance of the other arm. A third arm is divided into tenths, units, tens, hundreds and thousands of ohms. The unknown resistance to be measured is the fourth arm.

4. In shipbuilding, a partial deck extending from side to side of a vessel forward, and used by the officer in command as a convenient station to overlook and from which to give his orders.

5. In metallurgy, the low wall of division between the fuel chamber and hearth of a reverberatory furnace.

Bridge Arms.—The balancing arms of an electric bridge.

Bridge Balance of Telegraph Line.—In duplex telegraphy, a balance based upon

the principle of the Wheatstone bridge, such that the home receiving instruments, while ready to respond to signals received, will not respond to those transmitted from the home end.

Bridge Duplex.—The method of duplex telegraphy used principally in submarine cable practice; it involves the use of a Wheatstone bridge in obtaining a balance.

Bridge Method.—A method of measuring the resistance in a circuit by means of the *Wheatstone bridge.*

Bridge of Fuse.—A narrow space in a safety fuse connection filled in with a composition suitable for developing the heat of the electric current.

Bridges.—Copper bars designed to connect a dynamo to the *bus bars* in an electric lighting station.

Bridge System of Quadruplex Telegraphy.—An adaptation of the method of duplex telegraphy to quadruplex telegraphy.

Bridge Wall.—A transverse wall of firebrick placed in the throat of a *boiler furnace,* at the end of the fire grate. It prevents the admission of air except over or through the fuel, and forces the currents of flame and gases to traverse the crown of the furnace, and mingle together in so doing.

Bridge Wire.—In a Wheatstone bridge, the wire connecting with the galvanometer.

Bridging Bells.—Call bells in a bridging or multiple telephone system of party line working, bridged across the two sides of the line, and provided with magnets of high resistance and retardation.

Bridging Bell Telephone System.—A bridging, or multiple, system of party line telephone working in which the call bells at each station are permanently bridged across the two sides of the line, so that each call rings every bell in the circuit; a code of signals being used to distinguish the various parties on the line.

Bridging Coils.—In telephone practice, coils connected in bridge, or multiple, as opposed to *series* connected coils.

Bridging Indicator.—A shunt or parallel indicator in a telephone system, as distinguished from one in series connection.

Bridging Relay.—A shunt connected relay in a telegraph or telephone circuit.

Bridle Chain.—In submarine cable laying, a chain attached to a buoy, and so connected with the buoy rope that the rope may be readily picked up when the buoy is set free.

Bridle Wires.—1. Wires for making line wire connections into a cable box.

2. Wires which bring a telegraph station into connection with the line.

3. Wires for preserving the continuity of the circuit around "*anti-hum*" devices set in a telegraph wire.

Bright Deposit.—In silver plating, a process of securing a bright instead of dull deposit by adding to the plating bath a small quantity of *bisulphide of carbon.*

Bright Dipping.—Dipping a metal into acid to give it a bright surface in preparation for electroplating.

Bright Dipping Liquid.—The acid used for brightening metals in bright dipping.

Bright Red Heat.—In tempering, a stage of temperature when the black scales on the surface of iron are thrown into relief against the red background, and which corresponds roughly with a temperature of 1800° F.

Bright Work.—The polished parts of a steam engine or other machine.

Brilliancy.—The intensity, or strength, of a source of illumination.

Brimstone.—The common name for artificially prepared *sulphur;* so called from its burning qualities.

Britannia Joint.—A method of connecting lengths of telephone or telegraph wires, in which the two ends, after being carefully scraped, are laid side by side for a distance of about two inches, an inch or so at the end of each being previously turned up at right angles, then wound tightly together with several turns of binding wire, and the whole carefully soldered.

British Association Bridge.—A form of Wheatstone bridge used by the British Association for determining the B. A. ohm.

British Association Unit.—A value of the ohm as determined by the British Association, and as expressed by standard resistance coils of German silver; the B. A. ohm.

British Thermal Unit.—That quantity of heat required to raise the temperature of one pound of pure water one degree Fahr., at or near 39.1° F., this being the temperature of the maximum density of water; abbreviated B. T. U.

Broken Circuit.—A term denoting an electric circuit containing an air gap, or open space, so that no current can pass through it. Also called, *open circuit.*

Bromide.—In chemistry, a compound of bromine with a more positive radical; a salt of *hydrobromic acid.*

Bromine.—In chemistry, one of the elements, related in its chemical qualities to *chlorine* and *iodine.* It is a deep reddish brown liquid of a very disagreeable odor, emitting a brownish vapor at the ordinary temperature.

Bronze.—1. A varying alloy of copper and tin, with occasionally zinc or lead added. The copper varies from 80 to 90% and the tin from 10 to 20%. The greater proportion of tin makes a harder metal but decreases the tensile strength.

2. An alloy, similar in composition to that of tools found in the Pyramids of Ghizeh.

Bronzing.—Depositing a layer of bronze upon an object, by electroplating.

Bronzing Liquid.—A recipe for this material is as follows: mix together one oz. sulphate of copper, one oz. sweet spirits of niter, one pint of water. In three or four days it will be ready for use.

Brown & Sharpe Gauge.—The American wire gauge adopted as standard for wires for electrical purposes. The range of diameters measured by this gauge is from number 40 (=.00314 inch) to number 0000 (=.46 inch), the gauge numbers descending from 40 to 1, thence 0 to 0000. Like other standards, the gauge number decreases as the diameter increases; abbreviated B. & S. W. G.

Brush.—A device for drawing off from the commutator the electric current generated by the armature of a generator. Brushes are made in a variety of forms and of different materials, usually of copper or brass gauze; sometimes of metal strips laid together, bundles of wire carbon blocks, or small carbon wheels.

Brush and Spray Discharge.—A discharge of high potential resembling a spray of fine sparks, or a luminous brush, sometimes emitted from an electric conductor.

Brush Angle.—The angle formed by a brush and a tangent to the commutator at the point of brush contact. When the brushes do not bed properly the brush tips or ends have to be filed to the proper angle, usually about 45°.

Brush, Charles Francis.—Born 1849. An American inventor. He was employed as a chemist from 1869-1871, afterwards entering the iron industry in which he was engaged until 1875. In 1876, he perfected a dynamo which is known by his name, and, soon after, the series arc lamp. He has received over fifty patents since his original inventions, mainly on improved details of his dynamo and lamp. He established the Brush Electric Co., which controls his patents, and in 1899 he was awarded the Rumford Medal.

Brush Contact Surface.—1. That part of the surface of a commutator upon which the brushes rest.

2. That portion of a commutator brush which makes contact with the commutator surface.

Brush Electrode.—In electro-therapeutics, an electrode resembling a brush, for the medical application of electricity.

Brush Holder Cable.—A conducting cable directly connected to the brushes of a dynamo or motor commutator.

Brush Holders.—Adjustable clutches for holding the commutator brushes of a dynamo, feeding them forward to preserve the contact as they wear away, and permitting them to be lifted from contact when necessary.

Brush Loss.—The loss in watts due to the friction of the brush contacts against the surface of a commutator.

Brush Pressure.—1. The pressure with which the brushes bear upon the commutator of a dynamo.

2. The electric pressure or voltage delivered at the brushes.

Brush Rocker.—A rocker or "yoke" upon which the brush holders of a dynamo are

fixed so that the position of the brushes upon the commutator may be adjusted. When a dynamo is working, the neutral points, or the points upon the commutator where sparkless collection of the current can be made, vary in position as the load upon the dynamos varies, moving round in the direction of rotation as the load increases, and *vice versa*. It is necessary, therefore, in order to avoid sparking, to shift the brushes bodily upon the commutator from time to time, without in any way altering the adjustments of the brush holder springs or breaking the working circuit.

Brush Surface.—That portion of a brush that makes contact with the surface of the commutator.

B. T. U.—In mechanics, the abbreviation for British Thermal Unit.

Bucking.—In electric railway operating, a sudden and violent stopping of a car as the result of the opposition of one motor against another.

Buckled Diaphragm.—A warped condition of the diaphragm of a telephone transmitter or receiver, resulting in impaired efficiency.

Buckling.—The distortion occurring in the plates of a storage battery as a result of excessive discharge.

Buffing.—1. The process of making ready metal surfaces for electroplating, by polishing off with rapidly revolving wheels covered with rouge.

2. The polishing of articles which have been plated in order to give them the proper finish.

Buffing Lathe.—A machine used in polishing by buff wheels; known also as a *polishing bob*.

Bug.—A familiar name for any form of trouble encountered in the working of electrical apparatus.

Bug Trap.—A contrivance for overcoming a *bug* in electrical apparatus.

Building Iron.—In electrotyping, a tool shaped something like a poker, used when heated to apply melted wax to the mould in order to build it up before it is put in the plating bath.

Building Knife.—A tool resembling a knife, used in electrotyping to remove superfluous wax from the matrix.

Building Process.—In electrotyping, a process of building up the blank places in the mould to make corresponding depressions in the plate, by the application of melted wax by means of the building iron.

Building Switch.—A switch set in an electric circuit for the purpose of disconnecting a building from that circuit.

Building-up.—The active accumulation of electromotive force which a continuous current dynamo undergoes from the moment it starts till it reaches its maximum, as the result of mutual reaction and reinforcing of the currents generated in the armature and field magnet coils; the *reaction of a dynamo*.

Built-in Underground Conductor.—An electric conductor permanently and solidly built into a conduit with an insulating substance instead of lying detached and free.

Built-up Magnet.—A compound magnet consisting of a number of single magnets, separately magnetized and bound together.

Bullet Probe.—A probe with electrical connections for locating a bullet by making an electrical contact and giving a signal when the bullet is found.

Bunched Cable.—A cable enclosing two or more conductors.

Bunsen Burner.—A form of gas burner used for stoves, furnaces, and laboratory purposes, where a hot, non-luminous flame is required. It was invented by R. W. Bunsen. Its essential feature consists in drawing in a sufficient supply of air to promote complete combustion and mixing it with the gas beforehand. This is effected by means of a nozzle within a short tube, the jet of gas, rushing from this nozzle towards the burner at the far end of the tube, sucks in the air through openings in the side of the tube, and the gas and air mingle on their way to the burner.

Bunsen Cell.—A voltaic cell for experimental purposes devised by R. W. Bunsen. It is usually of circular shape, and contains a solution of sulphuric acid in which stands a cleft zinc cylinder; inside of that is an earthenware porous jar containing a rod of carbon immersed in strong nitric acid.

Bunsen Photometer.—A photometer employing a screen of somewhat opaque paper made translucent, except a central spot (or as to a central spot alone) by being satu-

rated with spermaceti, paraffin, or other suitable material; the screen is mounted upon a graduated scale, at one end of which the standard light is fixed, and at the other the light to be compared. By moving the screen along the scale until the spot becomes invisible, the relative illuminating powers of the two lights may be determined as the square of their distances from the screen; also called the grease spot, or translucent disc photometer.

Bunsen, Robert Wilhelm.—Born 1811, died 1899. A German chemist, for many years professor at the University of Heidelberg. His numerous discoveries contributed greatly to the progress of science. He discovered an improved method of spectrum analysis; the magnesium light; important principles in the nature of organic compounds; and many valuable facts in physical chemistry. He invented an ice calorimeter; a filter-pump; a photometer (1843); a primary electric cell; and the well-known Bunsen burner (1850) which furnishes a smokeless, non-luminous flame of high temperature. His numerous publications are of the greatest scientific value.

Bunsen Screen.—The movable disc of somewhat opaque paper, made translucent except for a central spot (or with a translucent center only), used in the Bunsen photometer.

Buoy, Electric.—A buoy which displays electric light signals.

Burette.—A glass tube usually graduated to fractions of a centimeter, used for accurately measuring out small amounts of a liquid.

Burglar Alarm.—A device attached to a door or window, to cause an alarm when opened from the outside.

Burglar Alarm Annunciator.—An annunciator connected with a burglar alarm system.

Burglar Alarm Contacts.—Contacts so adjusted to windows, doors, and other fixtures as to sound an alarm.

Burglar Alarm, Electric.—A device for making an electrical contact and sounding an alarm when a door, window, or any other point fitted with the alarm is disturbed.

Burglar Alarm Mat.—A mat furnished with electric contacts which ring an alarm when it is stepped upon.

Buried Cable.—A cable laid directly in the ground without being enclosed in a conduit.

Buried Transformer.—A transformer enclosed in a water tight case and buried underground.

Burned Out Incandescent Lamp.—An incandescent lamp which becomes exhausted after constant use, and ceases to give light.

Burner, Electric.—A gas burner fitted with a device for lighting the gas by an electric spark.

Burnettize.—A method of enabling wood to resist decay by saturating it with a solution of zinc chloride.

Burning at Commutator.—Injurious sparking and flashing at the contacts of the brushes with the commutator of a dynamo due to faulty adjustments, defective conditions, short circuits, overload of dynamo, etc.

Burnishing.—Polishing metal articles before and after electroplating, by tools of steel, agate, or similar hard materials.

Burn Out.—The damaging of any portion of an electric machine by the accidental passage through it of a violent current.

Burnt Deposit.—A dark colored sediment that is deposited during the process of electroplating when too strong a current is applied to the bath; also called, *black* deposit.

Bursting Charge.—In blasting, a small charge of fine powder, placed in contact with a charge of coarse powder to ensure the ignition of the latter. It is usually fired by electricity.

Bus Bar Connectors.—Connections for joining the ends of dynamo bus bars.

Bus Bars.—Heavy copper bars connected with all of the dynamos in a central station in order to receive the entire electrical output, and issue it to the distributing conductors of the system; omnibus bars.

Bus Bar Stand.—A stand for supporting a bus bar on a switchboard.

Bus Bar Voltmeter.—A voltmeter for measuring the electric pressure maintained between the positive and negative bus bars.

Bus Field Excitation.—A method of exciting a dynamo by applying a current taken directly from the bus bars.

Bushed Poles.—Poles of a dynamo field frame having extended pole shoes or pieces.

Bushing of Socket.—A small insulating cylinder inserted at the base of an incandescent lamp socket, affording insulation and protection to the conducting wires.

Bus Rods.—In electric lighting stations, heavy copper conductors, which receive the current from all the generators. Also called bus bars.

Busy Jack.—A jack in the switchboard of a central telephone exchange, so connected that by inserting into it the plug of any line the calling operator may be notified that the subscriber wanted is busy.

Busy Test.—In a multiple telephone switchboard, a method of notifying the operators at the different boards that any particular line is already busy, by causing a "click" to sound when any operator touches the tip of her answering plug to the test ring of that line.

Busy Test Lamp.—In telephony, a visual signal on the operator's switchboard consisting of a small incandescent lamp, used to indicate when a line is busy.

Butt Joint.—1. A method of joining lengths of wire by setting them end to end and welding or soldering them together.

2. An "end-on" joint in belting to secure even running for belt driven dynamos.

Button Repeater.—In telegraphy, a method of making the necessary connections for repeating a message by the turn of a button.

Butt Prop.—A pole having a U shaped iron fork attached to one end, used to support a telegraph pole while being raised. Also called *dead man.*

Buzzer.—1. An electric call signal which makes a buzzing noise caused by the rapid vibrations of a contact breaker. It operates on the same principle as the electric bell and can be adjusted to emit a musical and pleasing hum instead of the ordinary ringing.

2. In gas engines, a name sometimes applied to the *vibrator* or *trembler* of a jump spark ignition system.

B. W. G.—Abbreviation for Birmingham wire gauge, a British standard gauge.

By-pass of Discharge.—A path through an insulator, taken by a sudden electric discharge instead of through a conductor of very much smaller resistance. Also called alternative path.

B. & S. W. G.—Abbreviation for Brown & Sharpe's wire gauge, the standard American gauge for electric wires.

C.—1. Abbreviation for *capacity.*
2. Abbreviation for *Centigrade.*
3. Abbreviation for *coulomb.*
4. Abbreviation for *current.*
5. The symbol of electric capacity, or the farad.
6. As a numeral, C stands for Latin *centum* or 100, CC for 200, etc.

Cabinet Seat Contact.—A contact beneath the seat in a telephone cabinet, which is closed by a person's weight upon the seat.

Cable.—1. A single copper wire, or strand of such wires, heavily insulated and covered by a coated metal sheath or envelope, for the purpose of telegraphic communication or electrical distribution.
2. To dispatch a message by the submarine cable.

Cable Alphabet.—The code of signals for sending cable messages.

Cable Box.—A suitable box of iron or wood designed to shelter a cable head in overhead wiring.

Cable Buoy.—A buoy designed to float the end of a submarine cable during process of laying or repairing.

Cable Casing.—The outside coating or sheath of a cable.

Cable Cell.—A voltaic cell produced in a defective cable by a broken strand of the conducting core and the metallic sheath acting together as electrodes.

Cable Clearing House System.—A system of repeating a cablegram upon receipt back to the sending office for verification.

Cable Clip.—A clip for suspending an overhead cable from a messenger wire; a cable hanger.

Cable Closing Machine.—A machine for applying the outer covering to a cable.

Cable Code.—1. An alphabet for cable signaling.
2. A cipher for abbreviating cable messages.

Cable Core.—The inner conducting wire or strand of wires of a cable, as opposed to the insulation and sheathing.

Cable Cross Connecting Board.—A distributing board in a telephone exchange at the point where the outside cables are admitted into a building, designed to aid in making subscribers' connections with the switchboard cables.

Cable Currents.—Stray currents that may arise in a submarine cable line. They may consist of earth currents, or, in case of a break, currents which flow from the fractured end of the cable core to the metal sheath and so through the station apparatus.

Cable Despatch.—A telegraphic message sent by submarine cable; a *cablegram.*

Cable Drum.—A drum upon which a cable may be coiled to secure convenient handling.

Cable, Electric Light.—A cable which distributes the current to a system of electric lights.

Cable Fault.—A defect of whatever nature, which interferes with the proper action of an electric cable.

Cable Float.—A float upon which a submarine cable may rest to relieve the strain in the process of paying out; a cable resister.

Cablegram.—A message by cable; a cable despatch.

Cable Grapnel.—A grappling iron for the purpose of grasping a submarine cable and bringing it to the surface for inspection or repair.

Cable Grip.—A grip secured to the end of an underground cable so that it may be readily drawn through a conduit.

Cable Ground.—The scene of operations in submarine cable laying or repairing.

Cable Hanger.—A clip designed to hold an overhead cable to relieve the strain. It is suspended from a steel sustaining rope, called the *messenger wire.*

Cable Hanger Tongs.—Long handled tongs for suspending an overhead cable by means of hangers from the messenger wire.

Cable Head.—A sealed iron box within which are arranged terminals of overhead wires so that they may be assembled into a cable.

Cable House.—A small house built on the seashore to shelter the land end of a submarine cable.

Cable Jacks.—In line construction, a pair of supports for raising the axle of a cable reel so that the drum may freely rotate in paying out the cable.

Cable Joint.—An insulated connection for uniting lengths of cable.

Cable Junction Box.—A device for securing a perfectly insulated cable joint.

Cable Land Line.—A land telegraph line employing a cable instead of single exposed wires.

Cable Laying.—The operation of depositing a cable upon the bed of the ocean.

Cable Lead.—A lead composed of a number of conductors made up into a cable.

Cable Message.—A message sent or received by submarine cable; a *cablegram.*

Cable Office.—The station from which cablegrams are transmitted.

Cable Pillar.—In high pressure electric transmission lines, a pole of steel construction used instead of the ordinary wooden pole for carrying the feeder cables; a feeder pillar.

Cable Protector.—1. A contrivance for preventing injury to the insulation of a cable by discharging the electric charges induced in the metal armor by the varying E. M. Fs. in the core.
2. A fuse provided in the cable head terminal of overhead wires.

Cable Rack.—A rack set behind a telephone switchboard to support the cable containing the wires leading to that switchboard.

Cable Resister.—A float for relieving the strain upon a submarine cable in the process of paying out.

Cable Road.—A street railway line in which power is derived from an endless cable actuated by a central stationary engine, and running over pulleys between the rails or in a conduit beneath them; the cars are provided with a gripping lever to connect with the running cable. The cable road was the forerunner of electric traction.

Cable Sending Key.—A key for sending through a submarine cable the electric impulses necessary for the transmission of the message.

Cable Serving.—A hemp or jute coating wrapped about the core of a cable to relieve it from the weight of the external armor.

Cable Ship.—A specially designed vessel equipped with appliances for laying or repairing a submarine cable.

Cable Signals.—Signals received by submarine cable.

Cable Speaking Set.—The instruments employed in cable signaling.

Cable Spinning Jenny.—A contrivance for adjusting an overhead cable to the messenger wire; a *cable winder.*

Cable Splice.—A means of joining the sheathing at the ends of two sections of cable.

Cable Stop.—In electric elevators, a device to stop the winding machine and prevent the slacking of the cables upon the drum in case the car is obstructed in any manner in its descent.

Cable Switchboard.—A switchboard for the reception of wires introduced into a building by a cable.

Cable Tank.—A strong compartment on a cable ship, or elsewhere, for accommodating the coils of a submarine cable, either preparatory to laying, or for purposes of testing; a *cable well.*

Cable Telegraph.—The telegraphic outfit for transmitting messages by submarine cable.

Cable Telegraphy.—Transmitting messages through a submarine cable.

Cable Terminal.—An impervious cover applied to the exposed end of a telephone cable to protect it from moisture.

Cable Terminal Pole.—In overhead cable construction, the last pole on a line carrying the cable head.

Cable Terminal Switchboard.—An arrangement in a cable head which admits of the wires being fanned out, to separate binding posts, and then connected to terminals outside the box.

Cable Testing.—The application of pressure, strains, electric currents, etc., to a cable to test its quality before laying.

Cable Transformer.—A transformer for alternating currents in which the conductors are enclosed in a metallic sheath, like a cable.

Cable Vault.—A vault for the reception of underground cables where they enter a building, and in which the cables may be opened for the necessary connections.

Cable Well.—A compartment in a cable ship in which the submarine cable is wound before laying; a *cable tank.*

Cable Work.—Any work concerned with the making or handling of cables.

Cable Worming.—Hemp, or similar material, forming a core about which to wind the conductors of a cable.

Cadmium.—A white metal with bluish tinge belonging to the same chemical family as zinc, which it closely resembles. Cadmium and mercury in electrolytes of the sulphates of cadmium and mercury form the elements of the Weston standard cell.

Cadmium Cell.—A standard primary cell known as the Weston cadmium cell. Cadmium and mercury form the elements of this cell in electrolytes of the sulphates of cadmium and mercury. By the constancy of this cell and its freedom from temperature coefficient, it has largely superseded the Clark cell as a working standard.

Cadmium Plate.—A small plate of the metal cadmium attached to a wire for testing the voltage of a cell in a storage battery.

Cage Lightning Protector.—A wire lightning arrester built like a cage around the protected object.

Calamine.—An ore of zinc. It is zinc carbonate consisting of 64.8 zinc oxide and 35.2% carbon dioxide. It is found in many parts of Great Britain and the United States.

Calcium.—A rare white metal, rather harder than lead, having a specific gravity of 1.85 and melting at 189° F.

Calcium Carbide.—A compound of carbon and calcium which mixed with water produces acetylene. It is manufactured in an electric furnace known as a *carbide furnace.*

Calcium Light.—A very intense white light produced by the incandescence of a ball of lime in the flame of combined oxygen and hydrogen gases; lime light.

Calculagraph.—An instrument employed in long distance telephoning for recording the length of time during which a subscriber has use of the line.

Cal-electric Generator.—A generator operating on the principle of producing currents in the core of the secondary coil of a transformer by changes in temperature.

Cal-electricity.—Electricity generated in the core of a transformer coil by the influence of changes in temperature.

Calibrate.—To ascertain by special measurement, or by comparison with a standard, variations in the readings of a galvanometer or other instrument for electrical measurement.

Calipers.—Instruments to measure internal and external diameters or *calibres* of cylindrical pieces; they usually consist of two curved pieces of steel, hinged together with a tight joint at one end, the distance between the *points* representing the measurement taken.

Call.—1. A signal in telephone practice whereby a subscriber indicates to the central operator his desire to make use of the line.

2. A signal in telegraphy by which a remote operator demands attention, or calls for a response.

Callan Cell.—A primary cell consisting of a round outer cast iron cell, and an inner

porous jar containing a zinc cylinder in dilute sulphuric acid. The solution in the iron compartment is two parts sulphuric acid, two parts nitric acid, and one part water.

Calland Cell.—A primary cell used in French telegraphic work. It has a negative electrode of copper and a positive electrode of amalgamated zinc in an electrolyte of zinc sulphate, with crystals of copper sulphate as a depolarizer. It is sometimes called the *blue-stone* gravity cell.

Call Bell, Electric.—1. Any bell rung by electrical contact, usually upon pushing a button.

2. The electric bell which summons a telephone subscriber to answer the call.

Calling Circuit.—In a telephone system, the circuit which includes the calling apparatus and rings the call bell of a subscriber.

Calling Drops.—Drop shutters used in the switchboard of small telephone exchanges to indicate to the operator which subscriber is calling.

Calling Jack.—In a multiple telephone switchboard, a springjack into which the operator inserts a plug to call a subscriber.

Calling Magneto.—In telephony, a magneto generator and polarized call bell mounted together to form a calling apparatus.

Calling Plug.—A connecting plug for insertion into the springjack or socket of a telephone switchboard to effect a connection with, and to call up, the subscriber wanted.

Calling Side of Telephone Circuit.—The side over which a call is received.

Calling Station.—In telegraphy or telephony, a station signifying a desire to be connected with another.

Calling Wire.—The wire which makes up the calling circuit, sometimes used in telephony.

Call Key.—A key adapted to making an electric call signal.

Call Lamp.—A miniature incandescent lamp in a telephone switchboard which lights when a call comes through its circuit, and signals the operator; an indicator lamp.

Call Signal.—The telegraphic signal indicating the station wanted.

Call Wire.—1. A special wire between telephone exchanges for purposes other than to connect subscribers.

2. A wire by means of which a subscriber summons the central operator, and not available for interchange of conversation with other subscribers.

Call Wire Key.—A key by which a subscriber calls up the telephone operator.

Call Wire Switchboard.—A special switchboard in a telephone station where the call wire system is used, for the purpose of distributing the call wires among the different operators.

Call Wire System.—A system of telephone practice employing separate wires for the purpose of calling up the central station operators.

Calorescence.—The conversion of invisible rays of heat into light rays, by converging them to a focus upon a suitable substance which may thereby be heated to incandescence.

Caloric.—A term applied by *Carnot* to the supposed cause of the phenomena of heat, at the period when heat was supposed to be the manifestation of a substance called *caloric,* latent in all bodies.

Calorie.—The unit of heat in the C. G. S. system, equivalent to the amount of heat necessary to raise the temperature of a gram of water from 0° to 1° Centigrade; sometimes called the *smaller calorie,* and the *therm.*

Calorific.—In physics, a term meaning heating; heat producing.

Calorimeter.—An instrument used for measuring the heating power of coal. It consists of a strong steel vessel immersed in water, proper precaution being taken to prevent radiation. One grain of the coal to be tested is placed in a platinum tray within the steel vessel, oxygen gas is introduced under pressure of 20 to 25 atmospheres and the coal ignited by an electric spark. The heat generated causes a rise in the temperature of the water, from which may be calculated the heating power of the coal.

Calorimeter, Electric.—An instrument for measuring the heat generated by an electrical current in a conductor.

Calorimetric Conductivity.—The power a substance has of conveying heat.

Calorimetric Measurement.—The use of a calorimeter to measure heat quantities.

Calorimetric Photometer.—A photometer which measures the intensity of light by absorbing it in a thermo-electric battery, and then calculating the electric energy thus generated.

Calorimetry.—The process of measuring heat by the use of the calorimeter.

Calorimotor.—A voltaic battery consisting of one or more pairs of very large plates for producing heat effects.

Calory.—A common way of spelling *calorie*.

Cam.—A revolving disc, usually of a spiral eccentric, or heart shape, fixed on a shaft, or such other form as to impart to a lever, rod or block in contact with it, such velocity or alternating or *variable motion* as may be required.

Cam Governor.—A controlling device used in connection with Otto cycle gas engines; a stepped or differential cam is used giving three or four grades of valve lift; the action of the governor balls slides the roller on to one or another of these cams according to the centrifugal force of the balls.

Cam Plate.—An eccentric rotating plate, employed to produce reciprocating motion of an intermittent or irregular character.

Canal Rays.—When an electric discharge passes between the anode and a perforated cathode in a vacuum tube, pencils of light called *canal* rays, consisting of positively charged ions, are seen to pass through the holes in the cathode and produce phosphorescence against the glass.

Candle.—A unit of illumination; as, *one candle power*.

Candle Balance.—A balanced lever, or scale, used in photometric research to measure the rate of consumption of a burning candle by the indicated loss in its weight.

Candle, Electric.—An early form of arc lamp called, from its inventor, the *Jablochkoff candle*.

Candle Foot.—A unit of illumination; being the light given by a British standard candle at the distance of one foot. It is equal to 10.764 *candle meters*.

Candle Hour.—The period of time, in hours, a lamp burns before it loses 20% of its candle power, multiplied by the average candle power during that period.

Candle Lumen.—A term sometimes employed for the *lumen*.

Candle Meter.—A unit of illumination adopted outside of Great Britain, being the light given by a standard candle at the distance of one meter.

Candle Power.—The standard candle, by which all lights are measured, is legally held to be a sperm candle consuming 120 grains of wax per hour. The lights are compared in a *photometer* while a test is being made. In practical measurements, standardized incandescent lamps are more reliable and accurate than the primary standard. The standard unit of candle power established by the National Bureau of Standards at Washington equals $\frac{100}{90}$ of the Hefner unit under Reichsanstalt standard condition. According to experiments made by the Government of the United States, a 1 candle power white light is visible at a distance a little more than a mile, one of 3 candle power is visible at two miles; on an exceptionally clear night a white light of 3.2 candle power was readily distinguished at three miles; one of 5.6 candle power at four miles, and one of 12.2 candle power at five miles; a green or red 2 candle power light was visible at one mile, 15 candle power at two miles, 51 candle power at three miles and 106 candle power at four miles. See also international candle.

Canopy.—1. A metal cover set at the point where an electric light fixture or pendent enters a wall or ceiling, to conceal the connections.

2. An overhead frame in a telephone exchange, provided with plugs and drops.

Canopy Switch.—A switch placed under the canopy or hood of a trolley car for the purpose of shutting off the current from the motor and controller without pulling the trolley pole off the wire.

Cant Hook.—1. A lever for rolling and setting telegraph poles, provided with a heavy hinged hook near the end.

2. A lever and suspended hook adapted for turning timbers in the yard, on the skid or on the saw mill carriage.

3. A sling with hooks for raising and tilting casks, to empty them.

Canvas Strap.—A piece of canvas used by electroplaters and polishers to put a finish on those parts inaccessible by the brush or bob: the workman takes an end of the strap in either hand, the work being held by an assistant or between his own knees.

Caoutchouc.—(Pronounced *kó-chook*). The French spelling of the native South American name (*Cahuchu*) for the coagulated milky juice of various tropical trees and plants, which forms the gummy substance known as *india rubber*. Artificial caoutchouc is prepared from a thick solution of glue, by the addition of sodium tungstate and hydrochloric acid. This forms a precipitate which, after cooling, can be rolled into sheets and pressed into moulds.

Capability of Dynamo.—The greatest efficiency of a dynamo; it is mathematically stated as the square of the electromotive force divided by the internal resistance.

Capacity.—The quantity of electricity which a condenser is able to store or condense is known as its electrostatic capacity. The unit of capacity is called the *farad* and its symbol is *C*. A condenser is said to have a capacity of one farad if one coulomb of electricity is stored on each plate at a pressure of one volt between the plates. The farad being a large unit, the microfarad ($\frac{1}{1000000}$th of a farad) is generally used.

Capacity Balance of Duplex System.—In duplex telegraphy. a balance of capacity as distinguished from a balance of resistance.

Capacity Cage.—In wireless telegraphy, a cylindrical wire cage placed at the top of an ærial to increase its capacity.

Capacity Circuit.—A circuit having capacity without inductance.

Capacity Current.—1. The current arising from the electric capacity of a cable. 2. The current required to charge a telegraphic cable before a message can be sent.

Capacity Load.—The current strength of a dynamo dependent upon the capacity of its conductors as opposed to the actual current available for practical use.

Capacity of Accumulator.—The amount of energy which a storage cell is capable of accumulating; it is generally calculated in ampere hours; that is, the product of the number of amperes which the cell can discharge into the number of hours through which it can maintain that discharge.

Capacity of Cable.—The charge which must be given to a cable to raise it to unit electrical potential.

Capacity of Cable Tank.—The actual inside dimensions of a cable tank in cubic feet; or the amount of cable length that it can accommodate. In order to test a cable under its working conditions in deep water, the tank is closed and the portion of the cable within it subjected to hydraulic pressure approximating that to which it will be exposed when laid upon the ocean bed.

Capacity of Condenser.—The quantity of electricity with which it must be charged in order to raise its electrical potential from zero to unity. A condenser has a capacity of one farad when one coulomb is required to raise its potential from zero to one volt. The farad being a very large unit, the microfarad is generally used. Condensers from $\frac{1}{10}$ to 6 microfarads are the ordinary sizes.

Capacity of Leyden Jar.—The amount of electricity a Leyden jar is capable of holding divided by the difference of potential in the jar.

Capacity of Line.—The power a telegraph wire has of accumulating electricity in its mass.

Capacity of Polarization.—The quantity of electricity required to polarize a voltaic cell while in active use.

Capacity of Secondary or Storage Cell.—The amount of energy measured in ampere hours which a storage cell is capable of accumulating.

Capacity Reactance.—The reactance of an electric circuit due to its capacity; capacitance.

Capacity Resistance.—The resistance offered by any body possessing electric capacity to alternating electric currents.

Capillarity.—The peculiar action of a liquid by which its surface at the line of contact with a solid is raised or lowered. This action is best exhibited by the use of tubes of very fine bore, called *capillary tubes*.

Capillary Attraction.—In *physics*, a manifestation of the surface tension observed in all liquids. In fine tubes and bores the surface tension is sufficient to balance a small column of liquid, maintaining it at a level above the outside. This is very noticeable in small glass tubes, sponges, or

any porous substance such as loaf sugar. Where a liquid like mercury does not wet the tube, the behavior is different, as the level is maintained below that of the surface outside the tube; this is known as *capillary depression.*

Capillary Contact Key.—A contact key in which a wire makes contact with mercury to close the circuit.

Capillary Electrometer.—A form of electrometer which, when a current is passed through it, indicates difference of potential by the fall of a column of mercury in a capillary tube which joins on one side a tube filled with mercury and on the other a tube containing dilute sulphuric acid.

Capillary Tube.—A glass tube with a fine hair-like bore, employed to exhibit the phenomenon of capillary attraction.

Cap Screw.—A screw bolt intended to be used without a nut, so called because first used to secure the covers of small steam engines instead of studs. A cap screw is intended to be operated by a spanner, and therefore differs from a machine screw, which is turned by a screw driver. It differs from a set screw in that its point does not come into contact with any part to hold it. The heads are square or hexagon and generally deeper than those of a bolt of similar diameter.

Capsizing Thermometer.—A registering thermometer used for ascertaining the temperature of the sea depths; it is provided with a mechanism by which it is caused to turn over at any desired depth and make a record of temperature at the moment of inversion; a deep sea thermometer.

Cap Wire.—An overhead wire supported on the tip of a pole instead of on a cross arm.

Car.—The cage of an electric lift or elevator.

Car Annunciator.—An electric annunciator for the purpose of calling an attendant in a railway car.

Car Axle.—The shaft which passes through the hubs of car wheels, and on which the latter are shrunk or pressed. The wheels of cars are fastened to their axles in order that they may successfully withstand the severe strains and jars to which they are exposed by the weight and surging of the cars and the inequalities of the track.

The axle constructed of one-piece metal, and with the wheels fixed firmly thereon, is subject to severe torsional strain in turning curves, when the outer wheel has a circle of a larger arc to traverse, compelling the wheel on the inner and shorter circle to slip. The torsion of the axle is very detrimental and the slipping of the wheel is equivalent to grinding on the rail, and retards the train.

Carbide Furnace.—An electric furnace in which calcium and carbon are united at high temperature to form calcium carbide.

Carbide of Iron.—A highly crystalline form of cast iron. It is extremely hard and brittle, and contains nearly all its carbon in the combined state. Hence, called a carbide of iron.

Carbon.—1. One of the non-metallic elements; it exists almost pure in three forms, of which two are crystalline, viz.: the diamond, graphite, and the non-crystalline, charcoal.

2. The carbon pencil employed in an arc lamp as an electrode.

3. A prepared carbon for use in arc lamps. It is composed of carbon dust, powdered coke or gas carbon mixed with molasses, coal tar pitch or other carbonaceous cementing material, then moulded and baked.

Carbon Arc.—A voltaic arc occurring between carbon points; as, in an arc lamp.

Carbonate of Copper.—A similar salt to the carbonate of zinc, prepared for electroplaters by precipitation, by means of adding a solution of copper sulphate (blue vitriol) to a heated solution of sodium carbonate.

Carbonate of Lime.—The chief constituent of incrustation in boilers.

Carbonate of Magnesia.—Carbonate held in solution in some feed waters, and on deposition, producing incrustation in boiler tubes. It is usually present in smaller quantity than is the case with the carbonate of lime.

Carbonate of Zinc.—Normally occurs in nature as *calamine.* The precipitated carbonate is a double carbonate and hydrate and is prepared by mixing solutions of zinc sulphate and sodium carbonate, when it is thrown down as a white precipitate. Used for several purposes, notably by electroplaters in *brassing solutions.*

Carbon Block Lightning Arrester.—A device for protecting electrical apparatus from lightning, consisting of carbon blocks separated by an insulating material which compel the discharge to pass to the ground instead of through the apparatus.

Carbon Brushes.—Commutator brushes made of strips of prepared carbon, sometimes coated with copper to increase conductivity.

Carbon Button.—A button made of carbon employed as a resistance medium, especially in certain types of telephone transmitters.

Carbon Cell.—1. A primary cell having a carbon element.

2. A device composed of a silvered glass plate containing carbon powder, used as a photophone receiver.

Carbon Clutch.—A device for gripping the upper or positive carbon of an arc lamp so that it may be fed forward as it wears away.

Carbon Diaphragm.—The diaphragm of a variety of telephone transmitter consisting of a thin piece of compressed carbon.

Carbon Dioxide.—A colorless compound gas heavier than air, neither combustible nor a supporter of combustion. It is evolved by the combustion of fuels containing carbon, one atom of that element combining with two of oxygen from the air, to form this gas.

Carbon Disc Transmitter.—A form of telephone transmitter in which the diaphragm consists of a thin sheet of carbon.

Carbon Disulphide.—A colorless highly refracting liquid having an offensive odor because of impurities. It is prepared by pouring vapor of sulphur over strongly heated carbon.

Carbon Electrodes.—1. The carbon points of an electric arc lamp.

2. Carbon employed as the negative plate in a voltaic cell.

Carbon Filament.—An incandescent lamp filament composed of a thread or fiber which has been reduced to carbon by the carbonizing process.

Carbon Holder.—A device for holding the lower or negative carbon of an arc lamp.

Carboning.—Fitting carbons into arc lamps.

Carbonizable.—Capable of being reduced to carbon.

Carbonization.—The process of converting a substance into a residue of carbon.

Carbonize.—1. To subject a substance to intense heat in a closed vessel thereby reducing it to carbon.

2. To effect the destructive distillation of organic matters, as of coal in gas manufacture.

Carbonized Cloth Discs.—Discs cut out of cloth and carbonized for the purpose of offering a resistance varying with the pressure.

Carbonizer.—An apparatus for the purpose of carbonizing suitable substances.

Carbonizing Box.—A box designed for containing filaments for incandescent lamps while undergoing the process of carbonization.

Carbonizing Frame.—A carbon block upon which are wound the threads or filaments intended for incandescent lamps before they are carbonized.

Carbon Megohm.—A resistance equivalent to one megohm offered by a thin strip of carbon.

Carbon-mercury Coherer.—In wireless telegraphy, a form of detector in which a globule of mercury is held in light contact with electrodes of carbon. This type is known as the *auto-coherer* having the advantage over the filing coherer in the fact that it automatically restores itself to a sensitive condition without the use of a tapper.

Carbon Point Lightning Arrester.—A lightning arrester provided with carbon points between which the lightning stroke is discharged.

Carbon Points.—The carbon pencils or rods which form the essential elements in an electric arc lamp.

Carbon Rheostat.—A rheostat employing carbon plates or grains to effect the resistance.

Carbon Rod Microphone.—An early form of microphone in which the loose contact of one or more carbon rods against a sounding board or diaphragm served to intensify sound. The original type of telephone transmitter was constructed upon this principle.

Carbons.—1. The carbon pencils of an arc lamp.
2. The carbon electrodes of voltaic cells.

Carbon Steel.—A term applied to such steels as contain carbon alone (together with slight impurities such as phosphorus, silicon, sulphur, etc.), as distinguished from the numerous *alloy steels*, which may also be mixed with chromium, manganese, molybdenum, nickel, tungsten, and the like, for special purposes.

Carbon Telephone Transmitter.—A transmitter in which the vibrations of the diaphragm of the mouthpiece act with variable pressure upon finely divided carbon granules held between conducting plates. Early forms, now superseded, depended upon the change of actual resistance of a button or block of carbon under varying pressure.

Carbon Tongs.—A pair of tongs for the special purpose of grasping arc lamp carbons.

Carbon Transmitter.—A telephone transmitter employing carbon grains held between conducting plates for the purpose of transmitting the vibrations of the diaphragm.

Carborundum.—An abrasive material, resembling emery, but much harder. It is an artificial *silicide of carbon* formed in the intense heat of the electric furnace, the two elements not being combined in any manner in nature.

Car Brake, Electric.—A brake produced by the action of the motor of a trolley car when the current is shut off and the motor runs as a dynamo.

Car Brake Mechanism.—The mechanism which operates a brake.

Carcass of Dynamo.—The framework upon which a dynamo rests.

Carcel.—The French unit of illumination, equal to 9½ British candles; it is the light given by a carcel lamp burning 42 grams of colza oil per hour with a flame 40 millimeters high.

Carcel, Bertrand Guillaume.—Died 1812. A French clockmaker, inventor of the standard lamp which bears his name (1780).

Carcel Lamp.—The lamp burning colza oil used in France to establish the standard of light; it is named for its inventor, *B. G. Carcel.*

Carcel Standard.—The carcel lamp used in France as the standard of light.

Carcel Standard Gas Jet.—A gas burner of special design for the purpose of giving a definite illumination measured in carcels; it is used in comparing the power of electric lights.

Cardan Joint.—The *universal* or Hooke's joint used in machinery to permit flexibility of motion in a shaft.

Cardan Suspension.—A method of suspending the needle of a mariner's compass upon delicate hinges called gimbals.

Cardew Voltmeter.—A variety of voltmeter which indicates electric pressure by the passage of the current through a slender wire of platinum silver which thereupon expands and moves the index needle upon the scale.

Carhart Clark Cell.—A primary cell which is a modified form of the Clark standard cell. It has the same elements as the Clark, but the solution of zinc sulphate is saturated at 0° C. Its E. M. F. is 1.440 volt and its temperature coefficient about half that of the Clark cell.

Car Heater, Electric.—A heating apparatus for trolley cars composed of insulated coils for offering resistance to the passage of an electric current.

Carnot's Cycle.—The ideal or perfect engine cycle, or series of heat changes, devised by the French scientist Carnot (1824).

Carnot's Principle.—In physics, this principle is, that the amount of work done by a heat engine is independent of the nature of the intermediary agent employed, being dependent upon its temperature alone.

Car Propulsion, Electric.—The use of electricity as a motive power for street or other railroad cars.

Carriers of Replenisher.—The conducting plates of a replenisher which preserve the charges for accumulation.

Carrying Capacity.—The greatest amount of electrical current that a conductor can safely carry; it is expressed in amperes.

Carrying Capacity of Fuse.—The extreme strength of electric current which a fuse will bear before it melts.

Carrying Hooks.—A pair of hinged hooks fixed to heavy handles for gripping and carrying telegraph poles.

Cartridge Fuse.—A compact form of safety fuse consisting of a fusible wire or metal strip embedded in porous non-combustible material within a tube resembling a cartridge shell; also called, *enclosed* fuse.

Car Wiring.—The system of conducting wires required for the several circuits in a fully equipped electric car.

Cascade Charging.—The charging of Leyden jars or condensers by arranging them in series with the inner coating of one connected with the outer coating of the next throughout the series.

Cascade Connection.—A name sometimes given to the method of coupling up primary cells in a battery usually known as the *series* connection, in which the carbon of the first cell is joined to the zinc of the second, the carbon of the second to the zinc of the third, and so on for the entire number of cells, the first zinc and the last carbon being connected to the outer circuit.

Cascade Converter.—A motor converter employed to deliver constant potential direct current when supplied with high voltage alternating current. It consists of two machine structures with revolving parts mounted upon the same shaft. The input machine which acts as a frequency converter resembles an induction motor with a coil wound secondary, the output machine resembles a synchronous converter receiving energy from the secondary winding of the input induction motor at a frequency much reduced from that impressed upon the primary winding.

Case Hardening.—Hardening the surface of iron or low steel by tempering in a cyanide solution, so called from the skin or case formed upon the surface of the metal.

Case Wiring.—A method of interior wiring in which the wires are run along the walls and ceilings under suitable cleats.

Casings.—Grooved courses for interior electric wiring.

Casting, Electric.—A method of casting metals by the use of electric heat.

Cast Iron.—A carbide of iron, containing from 3 to 5% of carbon, both combined and as graphite, and about 2½% of silicon. This variety of iron, the production of the blast furnace, is valuable on account of the ease with which it can be melted and cast into moulds. It possesses great compressive strength, 90,000 lbs. per square inch, but is weak in tension, breaking at about 18,000 lbs., and is therefore used for building members in compression, and those parts of an engine, such as cylinder and bed plate, which are more easily cast to form than manufactured in other ways.

Castor and Pollux Light.—A name occasionally given to the peculiar electric discharge sometimes observed at the tips of a ship's masts and spars and known as St. Elmo's fire.

Cast Rail Bond.—A method of uniting the rails of an electric road at the joints, by casting iron around the lower part of each joint.

Cast Steel.—Steel, usually open hearth, which is cast into sand moulds like cast iron. The moulds require to be carefully made, and patterns should have more *draw* than for iron; furthermore, the castings should be removed from the sand as soon as possible and carefully annealed to prevent cracking or damage from internal stresses; the resultant casting is much stronger than cast iron. The same as *crucible steel*.

Catalysis.—In chemistry, a process by which reaction occurs in the presence of certain agents which were formerly believed to exert an influence by mere contact. It is now believed that such reactions are attended with the formation of an intermediate compound or compounds, so that by alternate composition and decomposition the agent is apparently left unchanged, as, the catalysis of making ether from alcohol by means of sulphuric acid. Also called, *catalytic action*.

Cataphoresis.—The action of electric osmose sometimes used as a method of introducing drugs into the human body.

Cataphoretic Action.—The medical application of the principle of cataphoresis.

Cataphoretic Demedication.—A process of removing injurious matter from the human body by cataphoresis.

Cataphoretic Electrode.—An electrode for the purpose of infusing into the human body medicine in solution by the process of cataphoresis.

Cataphoretic Medication.—A process of introducing medicine into the human body by cataphoresis.

Catchment Area.—In hydraulics, the extent of country drained by the springs and water courses which supply a waterworks.

Catenary Construction.—A system of overhead trolley construction employing a slack messenger wire with hangers at frequent intervals so as to maintain the trolley wire practically free from sag.

Cathion.—The element which appears at the cathode, or negative electrode in an electrolytic cell; the cation.

Cathodal.—Relating to the cathode.

Cathode.—1. The negative electrode in an electrolytic cell, the one which receives the current from the solution, and by which the current leaves the cell.

2. In electroplating, the object to be electroplated.

3. The negative electrode of a vacuum tube.

Cathode Cup.—The hollow, or concave cathode of an X-ray tube.

Cathode Pictures.—Pictures taken by the Roentgen or X-ray; *radiographs.*

Cathode Rays.—A peculiar radiation sent out from the cathode of a light vacuum tube when an electric current is passed through it, producing a golden green phosphorescence upon the glass walls of the tube opposite the cathode. This radiation is thought to be composed of negatively electrified material particles projected with great velocity from the surface of the cathode. Also called, cathode streams.

Cathode Ray Spectrum.—A spectrum consisting of parallel bands of phosphorescence separated by comparatively dark spaces, produced when cathode rays from an induction coil are influenced by a magnetic field.

Cathodic Reactions.—The reactions which take place at the cathode of an electro-therapeutic apparatus when it is in contact with the human body.

Cathodogram, or Cathodograph.—A name sometimes given to an X ray photograph or radiograph.

Cation.—The element or ion which appears at the cathode, or negative electrode, in an electrolytic cell; the electro-positive component; the *cathion.*

Catoptrics.—The branch of the science of optics which explains the reflection of light.

Caustic Soda.—Sodium hydrate. An alkali prepared by the reaction between sodium carbonate and slaked lime. Caustic soda is used in the purification of petroleum and sodium compounds. It is also employed as the *electrolyte* in the Edison primary cell.

Cauterization, Electric.—Cauterizing by the application of a wire heated by electricity.

Cautery Battery.—A multiple connected voltaic battery for the purpose of generating electric heat for the operation of cauterizing.

Cautery Cabinet.—A cabinet provided with all the appliances requisite for performing electric cauterization.

Cautery Cell.—A voltaic cell forming a part of a cautery battery.

Cautery, Electric.—In electro-therapeutics, the operation of cauterizing by means of wires or bands of platinum heated to an incandescent glow by the passage of an electric current.

Cautery Knife Electrode.—An electrode shaped like a knife blade for purposes of electric cauterization.

Cazin Lamp.—An early form of metallic filament lamp having a filament of secret composition. The lamp was never produced to a great extent. It gives a brilliant white light.

C. C.—Abbreviation for cubic centimeter, the unit of volume in the C. G. S. system of measurement.

Ceiling Block.—In incandescent electric lighting, an attachment of insulating material fastened to a ceiling containing the feed wire connection from which a pendant cord hangs; a ceiling rosette.

Ceiling Board.—An appliance for hanging an arc lamp.

Ceiling Bracket.—A bracket designed to carry insulated electric wires upon a ceiling.

Ceiling Cut Out.—A safety fuse fitted within a ceiling block; a rosette cut out.

Ceiling Fan.—An electric fan, hung from the ceiling.

Ceiling Rose, or Rosette.—An ornamental ceiling block for suspending an incandescent lamp.

Cell.—A single element of an electric battery, either primary or secondary, usually the former. It generally consists of a jar filled with a liquid or a pasty electrolyte, in which the electrodes are inserted or with which they are connected.

Cell Insulator.—In storage battery work, glass or porcelain insulators, sometimes containing oil, upon which each cell rests to prevent leakage along the floor.

Cell Switch.—The end cell switch of a storage battery.

Celluloid.—A hard, flexible substance formed from a mixture of camphor and pyroxylin, which is the same as gun cotton. The camphor is dissolved in alcohol, the gun cotton added, and the mass incorporated between rollers; it is then warm-pressed into the desired form. The coloring is usually added during the incorporation. It is highly inflammable, but non-explosive.

Celluloid Filament.—An incandescent lamp filament composed of a celluloid thread reduced to carbon.

Cellulose.—An organized structure of unknown chemical constitution, whose composition is allied to that of *starch*. It is insoluble in hot or cold water and all ordinary solvents.

Cellulose Filament.—An incandescent lamp filament prepared from wool which has been digested into cellulose form and then "squirted" through a die plate into alcohol by which it is set into a tough fiber and afterwards carbonized.

Celluvert Fiber.—A preparation used for insulating purposes.

Celsius Thermometer.—The *Centigrade* thermometer, so called from its inventor André Celsius, a Swedish astronomer.

Cement.—1. Any substance which causes bodies to adhere to one another, such as mortar, plaster of paris, glue, etc. Used without qualification, the term denotes *Portland cement*, also stucco, natural and Roman cements, etc.

2. Marine glue and other adhesive compounds having insulating properties suitable for electric work; electric cement.

Cement Arch Conduit.—A form of conduit for underground wires consisting of arched ducts composed of equal parts of Portland cement and sand moulded around wire gauze.

Cementation.—The oldest method of steel manufacture. Bars of wrought iron, of best quality, are buried in powdered charcoal within fireclay boxes, the whole being sealed or *cemented* with fireclay. These cementation boxes are placed within a furnace and brought to a bright red heat, the length of the heat depending upon the amount of carbon desired in the product; the process may continue for a fortnight with highly carbonized steels. From their being covered with blisters, the steel bars produced are known as *blister steel;* they are broken up, piled, heated in a reverberatory furnace, and subjected to rapid blows, which gives them a fibrous quality, forming *shear steel;* a repetition of the piling process produces *double shear steel,* also called, *crucible steel.*

Cement Copper.—Copper extracted from the water which is pumped out of copper mines. The water is pumped into tanks containing scrap iron, forming sulphate of iron and copper deposit. It is therefore almost in a state of chemical purity.

Cement Lined Conduit.—A conduit having its inner surfaces, or ducts, coated with a layer of cement.

C. E. M. F.—Initial letters used as an abbreviation for *counter electromotive force.*

Center Line.—1. A dotted or broken line shown in a drawing of machinery, denoting the *center* of an object; the lines of a force, or the limits of motion of the center of a vibrating part. On finished drawings, *center lines* are sometimes shown in red ink, to distinguish them from *dimension lines* which are usually blue.

2. A line marked centrally upon a piece of work on the *marking off table* from which dimensions are set forth.

Center of Distribution.—In an incandescent lighting system, a central point from which branch currents radiate to all parts of the system.

Center of Gravity.—That point in a body about which all the parts exactly balance one another, so that the body will remain at rest when supported, though acted upon by gravity: also called *center of mass.*

Center of Gyration.—In mechanics, that point in a body rotating around an axis, at which, if a given force were applied, it would produce the same angular velocity in a given time as it would if the whole mass of the body were collected at that point.

Center of Oscillation.—A point in a swinging body, as a pendulum, such that, if the whole mass of the body were concentrated there, the time of the oscillations would continue unchanged.

Center of Percussion.—That point, in a body revolving about an axis, at which it might be struck without causing any pressure on the axis; or that point at which if a blow be struck by the body the action is the same as if the whole mass of the body were concentrated at that point.

Center Pole Trolley System.—A system of line construction for double track street railways in which the trolley wires for both tracks are supported from the arms of a single row of poles set in the middle of the street.

Center Railway Line.—A street railway line having center pole construction.

Centi.—A prefix often used with a physical unit to designate the one hundredth part of that unit.

Centi-ampere.—A unit of electric current equal to the one hundredth part of an ampere.

Centi-ampere Balance.—An ammeter balance designed to measure the strength of electric currents in centi-amperes.

Centigrade Thermometer.—The *Celsius thermometer*, used in France and Germany, and in scientific work everywhere. In its scale 0° is the temperature of melting ice, 100° that of boiling water under the pressure of one atmosphere; hence the name *Centigrade*. Centigrade temperatures are converted into those of Fahrenheit's scale by multiplying the former by nine, dividing the product by five, and adding 32 to the quotient.

Centigram.—A measure of *weight* in the metric system; the one hundredth part of a gram.

Centiliter.—A *liquid measure* in the metric system; the one hundredth part of a liter.

Centimeter.—A measure of *length* in the metric system, equal to the one hundredth part of the length of a standard metal bar kept in Paris, called the *meter;* it is equal to .3937 inch.

Centimeter Gram Second System.—A system of physical units in which the centimeter is adopted as the unit of *length*, the gram of *mass*, and the second of *time*, the universal scale for physical, electric and magnetic constants. It is usually abbreviated to C. G. S. system.

Centimeter Gram Second Units.—The units of measurement of the C. G. S. system.

Centipede Cable Grapnel.—A form of cable grapnel having numerous prongs or grappling hooks.

Central.—The familiar name for a central telephone exchange.

Centrally Grounded Wire.—A wire running along the roadbed in a trolley system, connected to the rail bonds and grounded at fixed intervals.

Central Station.—1. In an electric distribution system, the power plant for generating current.

2. In telephony, the exchange through which subscribers are interconnected.

Central Station Burglar Alarm.—A burglar alarm system in which circuits lead from the protected points to some central location where the alarm is given.

Central Station Lighting.—An electric lighting system for buildings conducted from a central station.

Central Station Multiple Switchboard.—A central telephone exchange switchboard divided into sections; each section provided with springjacks or terminals for every subscriber entering the exchange.

Central Telephone Exchange.—1. The main exchange connected with branch exchanges.

2. The central station connected with individual subscribers.

Centrifugal Force.—The force which acts upon a body revolving in a circular path, tending to force it farther from the center of that circle. If the centrifugal force is just sufficient to balance the attraction of the mass around which it revolves, the mov-

ing body will continue in a uniform curved path. Should the centrifugal force increase, the body will either take up a larger path at a further distance from the center, or else tend to fly off in a straight line.

Centrifugal Governor.—A steam engine governor, in which the centrifugal force acts upon two or more revolving balls or weights. It is attached either to a throttle valve or the valve gearing and governs (*a*) by shutting off the steam supply as the velocity of the balls increases, also increasing the supply of steam as the velocity decreases, or (*b*) by changing the cut-off.

Centrifugal Pump.—A pump in which the moving part is a revolving wheel or fan with curved vanes or spokes. The liquid is admitted at the center of the fan, and being carried round by centrifugal force, escapes from the tip of the blades; often used for pumping the circulating water through a condenser.

Centrifuge.—A centrifugal machine for separating substances of different densities.

Centrifuge, Electric.—A centrifuge propelled by an electric current.

Centripetal Force.—A force which is supposed to impel a body towards some point as a center, and to act as a counterpoise to the centrifugal tendency in circular motion. The existence of such a force is disputed.

Cerium.—A rare metal, having a specific gravity of 5.5, having an appearance between iron and lead. It is found in the rare mineral *cerite.* The crude sulphate of cerium obtained from cerite is utilized in dyeing; the *dioxide* forms 1% of the mantle used in incandescent gas lamps.

Certificate.—A written and formal testimony to a fact. With engineers, it is a diploma showing that they have successfully passed an examination and are therefore legally qualified to hold a certain position. A *license*, on the contrary, is an official permit to hold a definite position, and is issued subsequent to satisfaction of the supervising authorities.

Cerussite.—Carbonate of lead; a valuable ore of lead when it exists in quantities; it is found either in crystals or massive; the lustre of the crystals is very brilliant.

Cessation of Current.—The breaking or ceasing of an electric current.

C. G. S. System of Measurement.—An abbreviation of *centimeter gram second*, the standard system adopted in chemical and electrical work. The *centimeter* is taken as the unit of distance or space, the *gram* is the unit of mass, and the *second* is the unit of time, the unit of velocity being 1 *centimeter in one second.*

C. G. S. Units.—Abbreviation for *centimeter gram second* units.

Chafe.—A worn spot on the outer coating of a submarine, or other cable resulting from chafing against some harsh surface.

Chain.—A series of links or rings, usually of metal, connected or fitted into one another; used for various purposes, as for support, connection, or the exertion and transmission of mechanical power.

Chain Block.—A pulley block, in which the rope fall is replaced by a chain; the ordinary *Weston* block is generally understood.

Chain Cable Grapnel.—A form of grapnel composed of chain links provided with grappling hooks.

Chain Drive.—A method of transmitting power to the driving axle of an automobile by means of a chain instead of a shaft and bevel gearing.

Chain Lewis.—A device for slinging stones, large masses of concrete, etc.; two curved pieces of steel are introduced into a lewis or dovetailed hole in the block, like)(. The strain on the chain through their upper extremities forces their points outwards and grips the stone to be lifted.

Chain Lightning.—A flash of lightning which appears in a long zig-zag or broken line.

Chain Oiling.—A self-oiling device applied to bearings in pillow blocks, hangers, etc., in which a small endless chain hangs over the shaft and dips down into an oil cellar beneath the bearing, thus bringing up a little oil as it revolves.

Chain Pull.—A short chain attached to the spark of an electric gas lighting attachment, or to the switch of an incandescent lamp, which turns the light on or off when pulled.

Chain Wheel.—A suitably formed sprocket-wheel as used in connection with the transmission chains of cycles, motor cars, etc.

Chain Winding.—A method of armature winding for alternating currents employing separate coils, the coils belonging to the same phase being connected in series; also called basket winding.

Chalk.—A nearly pure carbonate of lime, soft and earthy in texture. It is of marine origin, composed of the shells and remains of minute organisms deposited in deep water; used for polishing purposes.

Chamber of Incandescent Lamp.—The glass vacuum bulb containing the carbon filament.

Chamois Skin.—A soft fine leather prepared from various skins, by splitting and dressing them with fish oils. It is used for polishing purposes, and for wrapping polished metals. This material, also known as *wash leather*, derives its name from the *chamois*, a goat-like antelope of the Alps, from whose skin it was formerly prepared.

Chandelier.—A frame with branches to hold candle sockets; also an ornamental arrangement of pipes and fixtures to hold devices for lighting.

Change Over Switch.—A central station switch by means of which a circuit is changed from one dynamo to another; also called *changing* switch.

Change Ratio of Transformer.—The proportion of change effected in a transformer.

Change Speed Gear.—In an automobile, a number of pairs of cog or friction wheels, to produce different ratios of driving wheel speeds to engine speeds.

Change Speed Lever.—In an automobile, a hand lever by which are thrown into gear, either of the three or four trains of speed gears for forward running or the double train for reversing the motion.

Changing Switch.—A switch in a central station for changing a circuit from one dynamo to another, also called *change over* switch.

Channel Iron.—A form of angle iron having a web with two flanges extending only on one side of the web.

Characteristic Curve.—A diagram showing graphically in the form of a curved line the relation of changing values.

Characteristic Curve of Dynamo.—A curved line representing the varying pressures at the terminals of a dynamo for different loads. The curve is plotted on co-ordinate paper having the voltage values indicated by *ordinates* and the amperage values by *abscissas*.

Characteristics of Sound.—The peculiarities of different sounds which mark the distinction of one from another.

Charcoal Iron.—Wrought iron made solely with charcoal as fuel. This gives the best and purest iron, of great value in electrical work for transformer cores, armature discs, etc.

Charge.—1. In electrostatics, the amount of electricity present upon any substance which has accumulated electric energy. A static charge is measured in coulombs.

2. In storage battery work, the amount of current absorbed by the battery before it arrives at the condition of complete charge when it is ready for use. A storage battery charge is measured in ampere-hours.

3. In smelting, the body of ore, metal, fuel, or other matter introduced into a furnace at one time, for one heat, or one run as the case may be.

4. (*a*) The charge of a *puddling furnace* is about 500 pounds of pig iron, and this forms 4 blooms; (*b*) the charge of a *gas retort* is 220 pounds introduced in two scoopfuls of 110 pounds each; (*c*) the charge of a *tumbling box* is as many castings or other matters as it will conveniently contain and give room for mutual attrition.

Charge Current.—A current produced in a telegraph wire by the entrance of electricity into the line when the circuit is closed.

Charged Body.—Any substance possessing a static charge of electricity.

Charged Cell.—A cell in a storage battery containing an accumulation of electricity ready for use. A battery is completely charged when the voltage reaches a maximum value of 2.4 to 2.7 per cell, and the specific gravity of the electrolyte a maximum value of 1.2 to 1.4 per cell. The gas given off at the plates at this point increases in amount, and the electrolyte becomes milky or "*boils*." The positive plates of a charged battery are dark brown in color, and the negative plate light gray.

Charging.—Expending electrical energy in producing chemical change in the elements of a secondary battery so that electrical energy may be redeveloped by a secondary chemical change in the battery, by which the battery becomes a source of electricity.

Charging Current.—The electric current by means of which a storage battery receives its charge.

Charging Station.—A depôt where accumulators of electric vehicles, launches, etc., are charged with electricity.

Charles's Law.—In physics, the law that the volume of all gases varies as their absolute temperature, under constant pressure. Also known as *Gay-Lussac's Law.*

Chattering of Brush.—The rattling of a brush upon the surface of the commutator due to loose setting in the brush holder.

Chatterton's Compound.—An insulating preparation for electric conductors. It consists of 1 part, by weight, Stockholm tar, 1 part resin, 3 parts gutta percha.

Checking Action.—A dampening effect to reduce motion, as when the needle of an indicating instrument is caused to come quickly to rest by a damping device.

Checking Instrument.—An instrument employed in cable telegraphy for preserving records of messages as despatched by making impressions upon a recorder strip.

Check Nut.—A nut placed in contact with the main nut on the same bolt to keep the main nut from turning. More generally termed *lock nut.*

Check Valve.—An automatic or *non-return* valve used to control the admission of feed water into a boiler, etc. The pressure within the boiler keeps the valve upon its seat unless overcome by superior pressure caused by the pump or injector, thus permitting feed water to enter while preventing escape of the contents. Check valves on marine and other boilers sometimes have adjustable lifts, controlled by a wheel and spindle, but with the locomotive are generally non-adjustable, as only one boiler has to be considered.

Chemical Action.—The action taking place when a single substance or a number of substances re-act so as to produce a new substance or substances as distinguished from a *mechanical mixture.* The nature of the action may be dependent upon various conditions, as temperature, pressure, mass, light. An important phenomenon is that heat is either produced or absorbed by every chemical reaction. At very low temperatures, as about -300° Fahr. chemical action seems to cease.

Chemical Affinity.—The force which is exerted between molecules not of the same kind. To affinity is due all the phenomena of combustion, and of chemical combination and decomposition. Also called, *chemical attraction.*

Chemical Change.—A change which destroys the identity of the bodies undergoing it, as distinguished from *physical* change.

Chemical Compound.—A union of two or more ingredients, in definite proportions by weight, so combined as to form a distinct substance; as, water is a *compound* of oxygen and hydrogen.

Chemical Effect.—An effect resulting from the operation of chemical change.

Chemical Equivalent.—The atomic weight of a substance divided by its *valency.*

Chemical Formulæ.—Groups of chemical symbols, each of which indicates the composition of one molecule, employed to show the character of a chemical compound.

Chemical Generator.—A name given to a primary battery, as distinguished from a dynamo or mechanical generator.

Chemically Pure.—Without the admixture of any foreign substance whatever, such as could be detected by chemical tests. *Chemically clean* means cleaned by chemical means so that no dust or trace of any foreign substance remains on a surface.

Chemical Phosphorescence.—A phosphorescent glow consisting essentially of slow oxidation accompanied by the evolution of light; it is characteristic of the light of the firefly.

Chemical Photometer.—A photometer which measures the intensity of a source of light by the amount of chemical decomposition which the light can produce.

Chemical Potential Energy.—Potential energy existing in original atoms of matter.

Chemical Recorder.—The instrument at the receiving end of the line which records the message in a chemical automatic telegraph system. It consists essentially of a strip of chemically prepared paper moving over a cylinder, and a steel needle which decomposes the chemical solution with which the paper is impregnated. The chemically treated

tape upon the smooth metal cylinder serves as one electrode and the steel needle acts as the other in causing electrolysis.

Chemical Recording Meter.—An electric meter depending upon the action of electrolysis for registering the amount of electricity used.

Chemical Separation.—The disintegration or decomposition of matter as the result of chemical action.

Chemical Telegraphy.—A system of "automatic" telegraphy in which the messages are recorded by electro-chemical action effected by a metal pen in contact with a strip of paper treated with a chemical solution.

Chemical Telephone.—A telephone in which electrolytic action forms an essential feature of its working efficiency.

Chemical Velocity.—The time spent in effecting a chemical change considered in proportion to the amount of matter undergoing the change.

Chemism.—A general term for chemical action, force, or effects.

Chemistry.—The science which deals with the changes in composition and constitution which substances undergo.

Cherry.—The wood of the cherry tree. In Europe and Asia, it is that of the cultivated tree; in North America, that of the wild black cherry. The latter variety has a fine, straight grain; it is hard, strong and easily worked, being employed in cabinet work and interior finish.

Chief Operator.—The head operator in a telegraph office or telephone exchange.

Chill.—1. The casting of iron and steel in a metallic mould, which is kept cool by the circulation of water within it. Only certain varieties possess the property of chilling, but when successfully carried out it results in a very hard skin on the casting, the depth of which is sometimes as great as ½" to 1". Cast-iron wheels for cars are usually made by this method.

2. Reduction of temperature stopping short of actually freezing.

Chimes, Electric.—Chimes of bells which are made to ring under the influence of electrostatic charge and discharge to illustrate electrostatic principles.

Chimney Bracket.—A bracket designed to support an overhead wire or cable by attaching it to the corner of a chimney.

Chlorate.—A salt of chloric acid. All chlorates are soluble in water; on heating they evolve much oxygen and a trace of chlorine, the residue being a chloride. On account of their oxydizing properties chlorates are much used as reagents, and in the compounding of explosives, fireworks, matches, etc. The most important are the chlorates of barium, potassium and sodium.

Chloride.—A compound of an element with chlorine. The chlorides of non-metallic elements are either gaseous or liquid, those of metallic elements are liquids or solids. Some of these latter are decomposed by water, all the remainder save those of silver and some of mercury are soluble in water. A chloride is formed by direct union of the elements; by decomposition of a metal or its oxides or carbonate in hydrochloric acid: or by double decomposition, as with an insoluble chloride, such as that of silver.

Chloride Accumulator.—A trade name for a type of storage cell now extensively used. It gets its name from zinc chloride which was at one time employed in making the negative plate, though now abandoned. In the chloride cell, the positive plate is of the Planté type with metallic lead as active material, the negative plate being made by a special process.

Chloride of Antimony.—A strongly acid liquid of a reddish brown color, formed under heat by the action of hydrochloric acid upon native sulphides of antimony. This is really a solution of the *terchloride* in hydrochloric acid. Upon concentration the terchloride becomes a soft solid known as the *butter of antimony;* this is used with olive oil to *bronze* gun barrels, etc., and is also used by electroplaters as an oxidizing agent for silver, etc.

Chloride of Copper.—A white crystalline solid, insoluble in water but soluble in hydrochloric acid and ammonia. This salt is used in electroplating, etc.

Chloride of Gold.—This is formed by the action of aqua regia, or nitro-hydrochloric acid upon gold. The chloride is readily soluble in various liquids, is extremely susceptible to light, and is consequently much used in photography. It is also employed in electro-deposition.

Chloride of Lime.—Calcic chloride, prepared by passing chlorine gas over slacked lime in a gradual manner to avoid heating it. The chloride is used as a bleaching

agent, as a disinfectant; for the formation of brine used in refrigerating systems.

Chloride of Silver.—Formed as a precipitate by treating silver nitrate with chloride of sodium. It is extremely sensitive to light and is used to prepare the sensitive paper upon which photographs are printed from the negative. The chloride is also used by electroplaters in silver solutions.

Chloride of Tin.—In chemistry, a compound of chlorine with tin.

Chloride of Zinc.—A white solid, usually seen in the form of sticks, prepared in solution by the action of hydrochloric acid on zinc. This solution is generally known to tinsmiths as *killed spirits*, and is largely used in soldering with lead and tin alloys.

Chloride Storage Cell.—A type of cell having elaborately prepared negative plates in which lead grids are cast around small hexagonal slabs or "pastilles" of chloride of lead. These lead plates are placed in a solution of chloride of zinc and alternated with plates of metallic zinc, and then subjected to various processes which finally leaves an extensive area of porous metallic lead in contact with the solution. The positive plates are formed so as to present a large surface of lead peroxide.

Choking Coil.—A coil of wire provided with an iron core, and wound so as to give it considerable self induction with small resistance, used in an alternating current circuit to impede the current without loss of power; an impedance, or reactance coil.

Choking Effect.—The influence of a choking coil in retarding the current.

Chord Winding.—A method of winding a drum armature, in which each coil is laid on so as to cover an arc of the armature surface nearly equal to the angular pitch of the poles; also called, ***short pitch winding***.

Chromate of Lead.—A rare mineral found in Siberia, Hungary and the Philippines. It is known better as *crocoite* and is found in translucent yellow crystals. *Chrome yellow* is derived from this substance, which is also used in organic analysis and electroplating.

Chrome Steel.—Steel containing 1.2 to 1.5 % of chromium, which confers upon it extraordinary hardness and tenacity, rendering it suitable for projectiles, armor plates, safes, etc.

Chromic Acid Cell.—A primary cell employing as a depolarizer, chromium trioxide dissolved in water forming a mixture popularly known as chromic acid. This cell was formerly known as the potassium bichromate cell from the fact that originally the chromium trioxide was obtained from potassium bichromate. The plates employed are carbon and amalgamated zinc.

Chromium.—A white metal, very infusible, with a specific gravity 6.8, principally occurring in nature as *chrome iron ore*, which is found in the Shetland Islands, Bosnia and California. Alloyed with steel in small quantities, it produces a material of extreme hardness and tenacity, and its compounds and derivatives are numerous and useful. *Chrome alum* is employed in dyeing and calico printing; *bichromate of potash* is used for electrical purposes.

Chromosphere.—The red gaseous envelope around the body of the sun, outside the luminous photosphere.

Chronograph.—A timekeeping instrument of which the *stop watch* is the most familiar instance. The mechanism can be set in motion by pressing a spring and stopped by the same means, thus preserving a record of the time elapsed between the two movements.

Chronometer.—1. A finely made timepiece, whose balance wheel is specially adapted to keep accurate time in all variations of temperature. It has an escapement, more refined than that of a watch. For marine use, the chronometer is mounted on *gimbals* to preserve it from vibration and keep it horizontal. Chronometers are mounted in boxes, which are enclosed in a glass covered case, preserving them from dust, draughts and fluctuations of temperature. They are wound daily at a stated hour and are not regulated. The instrument is set as accurately as possible and its timekeeping qualities ascertained in an observatory. A certificate of *rating* is issued showing the *gain or loss* of the chronometer, and this cumulative error is taken into account when observing the time.

2. An instrument operated by electricity for measuring time, and adjusted for accuracy under changing conditions; called also *electric chronometer*.

Chronoscope.—An electrically controlled instrument for measuring time to the one-thousandth part of a second. It is by the use of a chronoscope that the speed of a projectile is sometimes measured.

Chute Case.—An annular casing surrounding certain types of turbine water wheels. The chute case contains the guide blades of one of the inward flow type, and is sometimes made double, the inner case acting

as a *register gate*, to regulate the flow of water.

C. I. F.—A commercial transportation term, meaning *cost, insurance* and *freight;* it is intended to cover the cost of certain goods at point of destination.

Cinder.—1. A small particle of matter remaining after combustion.
2. A scale thrown off in forging metal.
3. Uncombined carbon in wrought iron.

Cinematograph.—An electric machine for throwing a rapid succession of pictures upon a screen, and thus giving the effect of an animated scene; *a biograph.*

Cipher Code.—A telegraphic code employing arbitrary words or phrases in place of actual extended messages for rapid, economical and secret communication.

Cipher Message.—A message composed in terms of a cipher code.

Circle of Reference.—A circle of given radius employed in plotting out a curve of sines to illustrate periodic motion.

Circuit.—The course followed by an electric current passing from its source through a succession of conductors, and back again to its starting point.

Circuital Flux.—1. The electric flux of a circuit.
2. A circular flux.

Circuital Gaussage.—The magnetic intensity of a complete magnetic circuit.

Circuital Magnetism.—The magnetism of an ordinary bar magnet exhibiting poles only at its two ends.

Circuital Vector.—A vector quantity completing a curve or loop.

Circuital Voltage.—The voltage indicated in a complete electrical circuit.

Circuit Breaker.—A device, not unlike a switch, wherein a dangerous variation in the load upon an electric circuit, through properly arranged electro magnets, opens the circuit. Circuit breakers are made to operate on an overload or underload.

Circuit Indicator.—A type of galvanometer for showing the presence of an electric current and roughly indicating its strength.

Circuit Loop Break.—In overhead wire construction, a bracket carrying insulators for including a loop in the circuit.

Circuit Loop Break Insulator.—An insulator for making the connections in a circuit loop break.

Circuit Maker.—In ignition, a device which makes and breaks the primary electric circuit to produce a spark; the interval during which the circuit is closed being very small in proportion to that during which it is open.

Circuit Maker Bell Pull.—A mechanism which may be attached to a bell pull whereby an electric contact is made and a bell is rung.

Circular Bell.—An electric bell having all its mechanism enclosed within the gong.

Circular Current.—An electric current describing a circle in its path.

Circular Flux.—The magnetic flux employing an electrified conducting wire; circuital flux.

Circular Inch.—The area of a circle whose diameter is one inch; as distinguished from one square inch, and equals .7854 square inch. The circular inches in any circle is simply *the diameter in inches squared.*

Circular Magnetization.—Magnetization resulting in circular magnetism.

Circular Measure.—This is used for measuring angles:

Table.

60 seconds (″),	make	1 minute,	′
60 minutes,	"	1 degree,	°
360 degrees,	"	1 circle,	C.

The circumference of every circle, whatever, is supposed to be divided into 360 equal parts, called *degrees*. A degree is $\frac{1}{360}$th of the circumference of any circle, small or large. A *quadrant* is a fourth of a circumference, or an arc of 90 degrees. A degree is divided into 60 parts called *minutes* expressed by sign (′), and each minute is divided into 60 *seconds* expressed by (″), so that the circumference of any circle contains 21,600 minutes, or 1,296,000 seconds.

Circular Mil.—The area of a circle one mil ($\frac{1}{1000}$ in.) in diameter, used as a unit in measuring the cross section of wires. The square of the diameter of a wire in mils gives its area in circular mils.

Circular Millage.—The cross section of wires measured in terms of circular mils.

Circular Mil System.—A system of stating the size of electrical conductors with reference to a standard circular electric conductor. Its unit is the circular mil.

Circular Pitch.—The pitch of wheel teeth as measured along the circumference of the *rolling* or *pitch circle*, upon which one wheel comes into contact with its mate. Also known as *circumferential pitch*.

Circular Touch.—A magnetizing process by contact in which four metallic bars to be magnetized are arranged in a square and the magnet applied by a circular movement around the square thus formed.

Circular Units of Area.—A system of units of area adopted for measuring the cross section of wires by which areas are expressed in terms of a unit circle, such as the circular mil.

Circulating Pump.—1. In a power plant, a reciprocating or centrifugal pump maintaining the circulation of cooling water through a surface condenser, either by suction or forcing.

Circulation.—1. Motion in a circular course, or in one which brings the moving body back to the point whence its motion began.

2. In steam engineering, the provision of means within a boiler for the unobstructed motion of water from the coldest to the hottest part, thus aiding the passing of the feed water into steam. In raising steam, with large boilers having thick plates, forced circulation is employed when by use of the *hydrokineter* there is an auxiliary boiler in use. This prevents the great stresses thrown on the shell plating by a considerable difference of temperature between the bottom and top of the boiler, and also quickens the generation of steam.

Circumference.—The curved line that bounds a circle.

Circumferential Speed.—The rapidity of motion imparted to a point on the surface of an armature or wheel circumference by the rotation; also called, *tangential speed*.

Circumflux.—A quantity obtained by the product of the number of conductors on an armature and the armature current divided by the number of poles.

Civil Engineering.—That branch of engineering which deals with non-military public works. It embraces railways, roads, bridges, embankments, waterworks, harbor-constructions, canals, etc.

Clack Valve.—A pump valve which works on a hinge; generally the hinge and face are made of leather, the valve itself being of metal. So called from the noise it makes when seating itself.

Clamp for Arc Lamps.—1. A clamp for securing the end of the rod that holds the arc lamp carbon.

2. A carbon clutch.

Clamp Splicing Ear.—A splicing ear for trolley wires by which the ends of the wires to be joined are forced together by a clamping device and then securely bolted.

Clamp Terminals.—Terminals in the form of screw clamps for uniting the ends of wires.

Clapper Valve.—In steam engineering, a valve suspended from a hinge and operating on two openings or seats alternately. In a modified form, it consists of a disk vibrating between two seats.

Clark Cell.—A primary cell invented by Latimer Clark and adopted as the standard of E. M. F. by the International Congress at Chicago, in 1893. The positive element is mercury and the negative amalgamated zinc, the electrolytes being saturated solutions of sulphate of zinc and mercurous sulphate. At 15° C. the E. M. F. is 1.434 international volts. Before the introduction of the Weston cell, the Clark cell was almost universally used as a standard.

Clark, Latimer.—Born 1822, died 1898. An English engineer and electrician. He invented the gutta percha coating for underground wires; a submarine cable covering of asphalt, hemp and silica; the "double cap invert" insulator; and the Clark cell. He made important investigations relating to the action of electric currents in submarine cables, and was actively engaged in cable-laying in the South Atlantic and elsewhere. In other branches of engineering he also took active interest, notably in the construction of canals and floating docks.

Clark's Compound.—A compound of mineral pitch, silica and tar used as a protective covering upon the sheath of a submarine cable.

Clay.—A widely distributed earthy rock, derived from the disintegration of harder rocks, such as *feldspars* or *granites*, etc. The natural silicate is commonly mixed with variable proportions of sand, lime, iron oxides, magnesium or other minerals, and sometimes with organic matter. The common characteristic feature of all clays, which vary so

much in other respects, is *plasticity;* that is, upon moistening with water clay can be moulded into any desired shape; if this added water be evaporated the clay may be reworked, but if sufficient heat be applied to drive off the natural constituent of the hydrated silicate, the clay is burnt into a solid substance, no longer workable; as, *brick, kaolin, pottery,* etc.

Clay Electrode.—In electro-therapeutics, an electrode made of clay of such a shape as to fit the part of the human body which is to be subjected to medical treatment.

Clean Casting.—In a foundry, a casting having a clean skin. To produce a clean casting, the mould must be properly vented, sand suitable for the nature of the casting must be used, and the surface *sleeked over* with plumbago.

Clearance.—The open space occurring between the polar faces of the field magnets of a dynamo or motor and the surface of the armature.

Clearance Space.—In an engine compressor, or pump cylinder, this comprises not only the space left between the cylinder end and the piston but also the volume of the ports between the valves and the working barrel. In gas engines, etc., the clearance space serves as the combustion chamber and is necessary, but with steam engines it is sought to be minimized as with Corliss or drop valves. In any machine compressing a gas, its efficiency is much diminished by the effects of clearance, hence many devices are employed, especially with ammonia compressors, to reduce it to its least possible limits.

Clearing.—A term used in telephone practice for the process of disconnecting subscribers who have been using the line.

Clearing Out Drops.—Drop shutters in a telephone switchboard in circuit with any two connected subscribers, which fall when the use of the line has ceased.

Clearing Out Relays.—Relays for the operation of clearing out drops.

Clearing Signal.—A signal given in a telephone exchange when a conversation over the line has ceased.

Cleat, Electric.—A small block of suitable grooved wood, or other non-conducting material for securing electric wires to the walls or ceiling of a room.

Cleat Work.—A method of running electric wires along the walls or ceiling of rooms by the use of grooved cleats set at intervals; open work.

Cleavage Electricity.—Electricity resulting from the splitting of mica or other crystalline minerals.

Clepsydra, Electric.—An instrument which measures time by the gradual flow of water, regulated by electricity, through a small opening.

Click.—A short, sharp, non-ringing sound, commonly the result of an impact.

Click Wire.—A wire in a telephone switchboard which sounds a click to indicate that the subscriber called for is busy.

Climbers.—Spurs strapped to a lineman's boots to assist him in climbing a telegraph pole; also called climbing irons.

Clinker.—1. A compact mass formed by combustion or by partial fusion of certain mineral substances, especially in the manufacture of *Portland cement.* In this an incorporated mixture of lime and clay is burned at a glowing heat, the resultant *clinker* being subsequently ground to the required fineness of powder.

2. A heavy vitrified slag, formed in burning certain coals, which clings to the bars of the furnace and clogs its air supply.

Clip.—In telegraphy, a cutting short or clipping of signals due to defective adjustment.

Clipping of Signal.—A cutting short of telegraphic signals as the result of some fault or disturbance.

Clock.—An instrument or machine automatically recording the pulsations of a pendulum and consequently measuring time by the movements of hands over a dial graduated to the hours and their subdivisions, also by striking the hours on a bell or chimes. The motive power is obtained from the descent of a raised *weight* which drives a *train* of wheels moving at different velocities to record the various intervals of time. The tendency to acceleration on the part of the train is periodically checked by an *escapement,* which checks the advance of the wheels at regular intervals; the pressure of the gearing is transmitted to the *pendulum,* and gives to the latter sufficient force to overcome the resistances tending to bring it to rest. A pendulum is unsuitable for a portable time piece and is replaced by a *balance wheel* and spring, while a driving spring is substituted for the falling weight. Clocks are sometimes operated to a greater or less extent by electricity.

Clock Meter.—A meter for electricity regulated by clockwork.

Clock Register.—An instrument attached to a clock for registering the exact time of any event.

Clockwise.—Said of rotating parts of machinery, when they run right handed or as the *hands of a clock*, from left over to right. The reverse motion is termed *counter clockwise.*

Clockwork Feed.—A wheel mechanism for feeding forward the carbons in an arc lamp.

Closed Circuit.—A circuit permitting a continuous electric current.

Closed Circuit Alarm.—An alarm kept on closed circuit which rings when the circuit is broken.

Closed Circuit Cell.—A cell which can remain on a closed circuit without being impaired by polarization.

Closed Circuited.—Having complete electrical continuity.

Closed Circuited Conductor.—A conductor which forms a part of a closed circuit.

Closed Circuit Thermostat.—A thermostat resting on a closed circuit, which breaks the circuit as the temperature rises.

Closed Circuit Voltmeter.—A voltmeter in constant connection with the electric pressure it indicates.

Closed Circuit Working.—A method of telegraphic signaling in which the batteries at the terminals of the line are kept constantly in a closed circuit.

Closed Circular Current.—The current in a circular closed circuit.

Closed Coil Armature.—An armature so wound that the coils are connected together; the junction of each adjacent pair being joined to a segment of the commutator so that the whole forms a closed circuit.

Closed Coil Winding.—The method of winding by which the coils of an armature form a closed circuit.

Closed Iron Circuit Transformer.—A transformer having a core which makes a closed magnetic circuit; a non-polar transformer.

Closed Iron Magnetic Circuit.—A magnetic circuit having a continuous course through iron or steel.

Closed Loop.—A loop of conducting material in a closed circuit.

Closed Loop Parallel Circuit.—A multiple circuit having its conductors in closed loops between which the receptive devices are connected.

Closed Magnetic Circuit.—A magnetic circuit lying in an unbroken course of iron or other metal having strong magnetic properties.

Closed Magnetic Circuit of Atom or Molecule.—A closed magnetic circuit conceived to exist in an atom or molecule of matter.

Closed Magnetic Core.—A magnetic core of iron designed to secure a closed magnetic circuit for its field.

Closed Position.—The position of a switch arm when the circuit is closed; the make position.

Closed System of Parallel Distribution.—A system of distribution in incandescent lighting having separate circuits connecting groups of receptive devices with the source, as opposed to the *tree* system.

Closet System.—In electric lighting, a system of distribution in which the lamps are divided into groups, each group having its own circuit running back to the dynamos.

Closure.—The closing of a circuit.

Clown's Hat Curve.—A curve of electromotive force or current which undergoes rapid change in pressure, suggesting in shape the pointed hat worn by clowns.

Club Foot Electromagnet.—A horseshoe electromagnet having a magnetizing coil wound upon only one of its poles.

Cluster.—1. A number of things that are arranged close together, so as to form a *group;* an assembly or aggregation; as, a *cluster* of lamps.

2. A number of things of the same kind joined, or collected together so as to form a *bundle.*

Cluster Call.—A metallic sphere forming the central base of a group or cluster of incandescent lamps.

Clutch.—A device for gripping any object so as not to interfere with its occasional movement; as, the carbon clutch in an arc lamp.

2. A mechanical device for engaging or disconnecting two pieces of shafting in the same line, or a shaft and a wheel, so that they revolve together or are free, at will. Two broad classes are used, one with positive connections by means of projections which engage with suitable recesses called the *jaw* or *claw clutch;* the second is the *friction clutch*, operated by means of *cones, constricting pieces*, or *expanding shoes.*

Cm.—Abbreviation for *centimeter*, the unit of length in the C. G. S. system of measurement.

C. M.—Abbreviation for circular mil.

C. M. M. F.—Abbreviation for *counter magneto-motive force.*

Coal.—Vegetable matter compressed and mineralized so that it occurs in stratified fossil deposits. Chemical changes have reduced the oxygen originally contained, consequently increasing the percentage of carbon. The traces of the original vegetable structure are very few. Coals are classified as follows: 1, *Anthracite;* 2, *semi bituminous;* 3, *bituminous;* 4, *long flaming* or *cannel;* 5, *lignite* or *brown coal.*

Coal Breaker.—An apparatus with tooth-rollers used to break the masses of coal into convenient pieces for the market, and sort them through screens or riddles. In the Pennsylvania *anthracite* region the sizes of coal are:

Lump......	will not pass	mesh	of	4	Inches.
Steamboat..	"	"	"	3	"
Broken.....	"	"	"	2½ to 2¾	"
Egg........	"	"	"	2¼	"
Large Stove.	"	"	"	1¾	"
Small Stove.	"	"	"	1¼ to 1½	"
Chestnut...	"	"	"	⅞ to 1	"
Pea........	"	"	"	½ to ¾	"
Buckwheat.	"	"	"	⅜ to ½	"
Rice.......	"	"	"	¼	"

The household sizes are egg and stove.

Coal Bunkers.—Compartments for storage of coal fuel. On shipboard, their dimensions and shape depend entirely upon the size and class of vessel, and the nature of the service. Ashore they are usually *bins* of moderate size, with conical bottoms so as to be self-trimming, and are generally placed above the firing platform. In such case, an *elevator* or a *wagon hoist* is fitted, unless an elevated track for coal cars is erected over the bunker tops.

Coal Gas.—A complex hydrocarbon gas, containing about 90% of hydrogen and marsh gas, and 5% of heavy carburetted hydrogen and acetylene. It is produced from the destructive distillation of coal, heated out of contact with air, in iron or fire clay *retorts.* The products of distillation are first cooled in *condensers* to free them of suspended coal tar and ammoniacal liquor; are then passed through *scrubbers*, or towers filled with wet coke, to dissolve out the ammonia; next through *purifiers* in which trays of slaked lime or ferric oxyhydrate absorb sulphur and carbon dioxide from the gas; finally being stored in a *gasometer*, preparatory to distribution as an illuminant.

Coal Oil.—A colloquial expression in certain districts for *petroleum*, and also for the illuminating oils derived therefrom.

Coal Tar.—Condensed during gas manufacture from bituminous coal, in the form of a thick black liquid. In the hands of the modern chemist it is the source of many by-products; such as brilliant *aniline dyes; carbolic acid;* medicines, as *antipyrine; saccharin* for sweetening; *creosote* for preserving wood, etc.

Coal Tar Oils.—Certain oils distilled from coal tar. The first distillates are light oil, heavy oil, creosote oil, and anthracene or green oil; and these are further separated into their constituents, such as benzine, naphtha, carbolic acid, naphthalene, etc.

Coarse Winding.—The few turns of thick insulated wire joined in series with the armature, employed in winding the field magnet of a series wound or compound wound dynamo.

Coating.—In metallurgy, the process of covering metals with a superior metal as gilding, plating, silvering, galvanizing, platinizing, etc.

Coatings of Condenser.—The thin layers of tinfoil placed on opposite sides of a condenser to receive the electric charge; without such coatings the charge and discharge would be very slow and would operate by degrees only, as one part of a non-conducting surface might be densely charged and another part be quite devoid of sensible charge; sometimes called the armature of a condenser.

Coatings of Leyden Jar.—The layers of tinfoil spread upon the outer and inner surfaces of a Leyden jar.

Cobalt.—A tough, lustrous, reddish white metal of the iron group, not easily fusible and somewhat magnetic. It occurs in nature in combination with arsenic, sulphur and oxygen, and is obtained from its ores, *smaltite, cobalite,* etc.

Cobalt Plating.—Depositing a layer of cobalt upon an object by electroplating. The baths employed for cobalt plating are chloride of cobalt, double chloride of cobalt and ammonium, or the double sulphate of cobalt and ammonium. Cobalt plate resembles nickel plate, and articles coated with cobalt are sometimes designated "superior nickel plate."

Cock.—In mechanics, a device for regulating the flow of fluids through a pipe; usually consisting of a tapered conical plug having a hole or port in it, and working in a shell of iron or brass bored out to receive the plug, and provided with passages to connect with pipes, etc., at either end. Rotation of the plug controls the passage of the fluids by bringing the openings in the plug opposite those in the shell, or away from them. The particular use or construction of any cock is generally shown by its name, as *blowdown cock, angle cock,* etc.

Code.—A system or arbitrary arrangement of signals for effecting communications at a distance. The codification may simply be for the sake of brevity, or as a means of secrecy, the latter constituting a *cipher code.* Specific examples are:

1. Signal Flags; the representation of short phrases, names, common words, syllables or letters by means of arrangements of different colored flags or single flags. This constitutes the *Universal Maritime Code,* which bears the same meaning in all languages. For naval use, each navy has its private code, wherein flags denote numerals, and the combinations of numerals correspond to words, phrases, or orders, arranged in series in a book.
2. Dot and Dash; alphabetic signaling, similar to that of Morse used in telegraphy, whereby signals are made over long distances, by waving of small flags, by colored lights, heliograph or similar means.
3. Telegraphic; a system of words, a maximum of ten letters being permitted, which represents other words, phrases, or numbers, to secure brevity and secrecy. As an instance, by using words as numbers, a code message of 141 ten letter words has been expanded to 70 pages of typewritten foolscap.

Code Messages.—Messages made up of code words instead of the actual words of a communication, thereby greatly abbreviating the dispatch.

Code Name.—A word or symbol agreed upon by any two correspondents as an abbreviated substitute in telegraphic communication for any actual name or term.

Code Telegraphy.—The use of code words in telegraphy in place of the extended message to save time and cost, and to secure secrecy

Code Time.—The signals used at the beginning of a telegram to indicate the time it was sent.

Coefficient.—In mathematics, a number or letter affixed to a quantity, to show how many times the quantity is to be taken. Hence a coefficient is a multiplier or factor, and when it enters into a formula represents some known value, usually found by experiment.

Coefficient of Electromagnetic Inertia.—The coefficient of self-induction ; being the quantity of induction in a circuit per unit current in it.

Coefficient of Expansion.—The ratio between the increase of volume which a substance undergoes when its temperature is raised by one degree C., and its original volume; thus, in the Centigrade scale the coefficient of expansion of air per degree is $.003665 = 1/273$; that is, the pressure being constant, the volume of a perfect gas increases $1/273$ of its volume at 0° C. for every increase in temperature of 1° C. In Fahrenheit units it increases $1/491.2 = .002036$ of its volume at 32° F. for every increase of 1° F.

Coefficient of Friction.—The ratio of the force required to slide a body along a horizontal plane surface to the weight of the body. It is equivalent to the tangent of the *angle of repose;* that is, of the angle of inclination to the horizontal of an inclined plane on which the body will just overcome its tendency to slide.

Coefficient of Hysteresis.—A certain constant measuring the work spent in taking one cubic centimeter of iron through one complete magnetic cycle.

Coefficient of Inductance.—The coefficient of self-induction; being the induction in an electric circuit per unit current in it.

Coefficient of Induction.—The ratio between the magnetic flux density of a magnetic substance and the field intensity; also called, the *magnetic permeability.*

Coefficient of Magnetic Induction.—The ratio between the magnetic flux density of a magnetic substance and the field intensity; also called, *magnetic permeability.*

Coefficient of Magnetic Leakage.—The ratio of the lines of force which pass away through the air and are wasted, to those which are utilized through the armature of a dynamo or motor.

Coefficient of Magnetization.—A term sometimes applied to magnetic susceptibility, which is the ratio between the intensity of magnetization acquired by a magnetic substance and the magnetizing force acting upon it; its symbol is the Greek letter *k* (kappa).

Coefficient of Mutual Inductance or Induction.—The number of lines of induction due to unit current in one circuit which passes through a second, is known as the coefficient of mutual induction between the two.

Coefficient of Self-induction.—The quantitv of induction passing through a circuit per unit current in it; also called *inductance*. It is measured in terms of the *henry*.

An inductance of one henry exists in a circuit when a current changing at a rate of one ampere per second, induces an electromotive force of one volt in the circuit. The *millihenry*, or the one-thousandth part of a henry, is often used as a more convenient unit.

Coercive Force.—The magnetizing force necessary to remove all the magnetization remaining in a piece of magnetic material after the magnetizing force has been discontinued.

Coherence.—The act of cleaving or sticking together; cohesion.

Coherer.—A device for detecting the presence of electromagnetic waves, usually consisting of a glass tube containing metallic filings making a connection between two electrodes, or, sometimes, two minute metal spheres in light contact; it is an essential part of the receiving apparatus in the Marconi system of wireless telegraphy; also called, *the detector*.

Coherer Tube.—In wireless telegraphy, a small glass tube, in which a partial vacuum has been made, containing nickel and silver filings which cohere and make a circuit when an electromagnetic impulse is received; also called, *filings-tube*.

Cohesion.—In physics, the principle or property by which the particles of a substance hold together, opposed to *repulsion*. In *solids*, cohesion is greater than repulsion, especially in the case of metals; with *liquids*, the two forces are about balanced, while in *gases*, the force of repulsion is far greater than that of attraction.

Coil and Plunger.—An electromagnet consisting of a hollow coil or spool having a free core which, upon the passage of an electric current through the coil, is drawn into it; *a solenoid*.

Coil, Electric.—Successive turns of insulated wire which create a magnetic field when an electric current passes through them.

Coil Heater, Electric.—A heating apparatus which produces heat by the resistance offered to the flow of electricity through a coil of wire.

Coiling Space of Cable Tank.—The space in a cable tank designed to hold the coils of the cable.

Coil Vaporizer.—A device for producing vapor from a volatile liquid by passing the latter through a coil, heated externally by a flame, etc. Used in certain types of lamps burning naphtha and the like, and in *petroleum engines*.

Coke.—The result of the distillation of coal. It is carbonized in heaps, in ovens, or in the retorts of gas houses; the bulk of the mass is increased by coking, the weight diminished from 30 to 35% according to the mode of conducting the process. It is used for fuel in manufacturing and household purposes, also for filtering purposes.

Coked Core of Filament.—The core of a type of incandescent lamp filament composed of carbon reduced to coke by electric heat.

Coked Filament.—An incandescent lamp filament of carbon which has been electrically heated in a vacuum to such a degree as to reduce it to coke.

Coking.—1. The manufacture of coke from coal.

2. The process of reducing carbon to coke by electricity; as, when a carbon filament is reduced to coke by electric heat in a vacuum.

Coking Process.—The application in a vacuum of an intense electric current to a carbon filament whereby it is reduced to coke.

Cold.—An expression for the opposite of heat; when exposed to a temperature below the average, the sensation experienced is called *cold*. Properly speaking, there can be no such thing as cold; only a greater or less degree of heat, at any point above that of absolute zero.

Cold Drawn.—A term applied in connection with wire or seamless tubes, which are drawn to size through rolls or dies while *cold*.

Cold Rolled Shafting.—Round shafting rolled to exact size while cold; the passage through the finishing rolls produces a smooth polished surface resembling the effect of planishing on sheet metals. Turning is unnecessary on these bars, and the unbroken "skin" renders it very strong.

Cold Soldering.—A process of amalgamation of metallic surfaces by the aid of mercury. A hard amalgam is made of five or six parts of pure silver, three or four parts of tin and 3 to 5% of bismuth. This alloy is melted and cast into ingots, the ingots reduced to fine filings, and those filings mixed when required, with enough mercury to form a stiff paste, which hardens in about an hour.

Cold Water Test.—The ordinary test of boilers, cylinders, pipes, etc., by water at ordinary temperatures, as distinguished from a test in which warm water or steam is employed. Also called, *hydraulic test*.

Collapsing Pressure.—In steam engineering, the pressure which, applied to the outside of a tube, causes it to fail by bending or crumpling inwards. In its usual application, it has reference to the tubes and fire boxes of steam boilers.

Collar.—In engineering, an enlarged cylindrical portion of a shaft, or a cylindrical ring or sleeve secured upon the shaft, in either case to serve as an abutment for securing something or preventing longitudinal movement of the shaft itself; as, a *set collar*.

Collar Bearing.—A bearing provided with several rings or collars, to take the thrust of a shaft, or in the case of a vertical shaft, to provide adequate surfaces for lubrication.

Collar Gauge.—A ring or internal gauge for testing the dimensions of external cylindrical pieces: the corresponding gauge for testing cylindrical holes is the *plug*.

Collation.—The repetition of a telegram by the receiving operator back to the sending office in order to verify it.

Collecting Ammeter.—A central station ammeter which accumulates the currents of the various dynamos so as to show the total output of the station.

Collecting Brushes.—Conducting devices which make sliding contact with the surface of the commutator or with the contact rings of an alternator, so as to draw off the current generated in the armature coils.

Collecting Combs.—Comb shaped devices for collecting electricity from the plate of a frictional electrical machine.

Collecting Panel.—A switchboard panel for collecting the current from the various dynamos controlled by that switchboard.

Collecting Rings.—Insulated metal rings so attached to the armature of an alternator as to communicate the alternating currents to the contact brushes without commutation; also called, collector rings or slip rings.

Collecting Vessel.—In steam engineering, a cylindrical vessel enclosed in a steam boiler for the purpose of collecting the muddy ingredients contained in the water, which would otherwise produce scale and cause incrustation. The vessel is perforated to admit the water which bubbles over into it, carrying over also the sediment, the last settling down into the smooth water within the vessel, to be subsequently blown out at intervals.

Collectors.—1. Devices, such as brushes and collecting rings, for drawing off electric current from the generating machine so that the electricity may be utilized.

2. The pointed combs or connections leading to the prime conductor on a static machine for collecting the electricity.

Collet.—1. A small metal ring used for various purposes.

2. A ring, collar or flange secured upon an arbor or spindle.

3. The disc or ring which holds the dies in a screwing machine

4. A small socket for holding a drill or bit.

5. The ring used to retain metallic packing in a stuffing box.

Collodion.—A solution of pyroxylin (soluble gun-cotton) in ether containing a varying proportion of alcohol. It is strongly adhesive and is used by surgeons

as a coating for wounds; but its chief application is as a vehicle for the sensitive film in photography. Collodion was at one time experimented with as a material for incandescent lamp filaments.

Colloids.—Uncrystalline semi-solid jelly or glue-like bodies which diffuse slowly and have no tendency to pass through porous membranes; opposed to *crystalloid*.

Colombin.—A mixture of barium and calcium sulphate used as a heat resisting insulation between the carbons of a Jablochkoff candle.

Color.—A property, depending on the relations of light to the eye, by which one is capable of distinguishing individual and specific differences in the hues and tints of objects. The sensation of color is due to differences in the *wave lengths of light*, the portion of the rays which is not absorbed by a surface giving it its distinctive color.

Coloring.—In electroplating, the employment of special salts in the dipping baths, intended to produce shades and tints of colors on the plated articles other than those due to simple metals; as, gold, silver, copper or nickel.

Column, Electric.—An early name for voltaic pile.

Colza Oil.—A pale yellow oil expressed from the seeds of the rape plant, having a specific gravity of .912—.920 at 60° F. The oil is used as an illuminant and a lubricant; for the latter purpose it is *blown;* that is, has air blown through it while heating; the blown oil may be used alone or mixed with mineral oil.

Comb—A collector of electricity used on influence or frictional electric machines, it consists of a bar from which a number of teeth project like the teeth of an ordinary comb.

Combination Bracket.—1. In telegraph or telephone pole line construction, a bracket for more than one insulator.

2. In lighting, a bracket adapted for both gas and electric lamps.

Combination Fittings.—Fittings for chandeliers designed for both gas and electric lights.

Combination Fixtures.—Gas fixtures that provide for electric lamps as well as gas.

Combination Gauge.—In steam engineering, a dial gauge which has two sets of registers; as, pressure and vacuum, pressure and heat of water, pressure and heat of steam.

Combination Lightning Protector.—A lightning protector for telephone circuits combining the film and fuse action, thus grounding the circuit when either the pressure or the current is excessive.

Combination Line Protector.—A combination *lightning protector*.

Combination Rheostat.—A rheostat which offers resistance through a series of independent coils.

Combination Three Phase Winding.—A method of connecting the coils of three phase alternators by combining the *star* and *mesh* windings.

Combined Carbon.—In chemistry, carbon which has entered into true chemical combination with iron to form white pig iron, steel, etc., and is not perceptible to the eye; as distinguished from the *graphitic carbon* that is mixed rather than combined, and which gives the gray appearance and comparative softness to cast iron.

Combined Fiber and Spring Suspension.—A method of suspending a magnetic needle by a fiber, or wire thread, combined with a spring, thereby minimizing the effect upon the instrument of the rolling of a ship or any similar motion.

Combining Weights.—In chemistry, the proportions in which elements or compound substances react upon each other; they are either the same as the atomic or molecular weights of the various substances, or a simple multiple or factor of those weights.

Comb Lightning Arrester.—A lightning arrester composed of two metal plates, having comb like teeth, connected to the line wire, and a third similar plate connected with the earth; a saw tooth or serrated lightning arrester.

Comb of Storage Battery.—The perforated lead plate used in storage cells; *the grid.*

Combustion.—The act or state of burning; properly, a chemical union of substances, whose combination is sufficiently energetic

to evolve heat and light. Thus, the combustion of ordinary fuels is due to the rapid combination of the *carbon* contained in the coal, coke, or wood, with the *oxygen* of the atmosphere.

Combustion Chamber.—In boilers, a portion of the internal heating surface arranged so as to afford space for better commingling of the furnace gases; for instance, in a flue and return tubular boiler, the hot gases pass from the furnace through large tubes or flues to the *combustion chamber* at the further end of the boiler, thence they return through small tubes to the uptake and funnel.

Come Along.—A clamp used in pole line construction for gripping a telegraph or telephone wire so that it can be drawn up to the required tension.

Commercial Efficiency.—The ratio between the practical or working efficiency of a machine and the total energy absorbed in producing that efficiency; *net efficiency.*

Commercial Efficiency of Dynamo.—The ratio between the available electric output of a dynamo and the total energy consumed in running it.

Commercial Efficiency of Motor.—The practical mechanical energy delivered at the pulley shaft of a motor, divided by the electrical energy absorbed in driving the motor.

Common Battery System.—In telephony, a system of signal transmission in which, by centralizing the transmitter batteries and calling current generators at the exchange, it becomes possible for a subscriber to signal the central office by simply removing the receiver from the hook, and again by replacing it, thereby greatly simplifying the apparatus and methods employed in the old magneto system.

Common Relay of Quadruplex System.—In quadruplex telegraphy the "neutral" relay or that one which operates by a change in the current strength.

Common Return.—A single return conductor for several circuits.

Commutated.—Said of electric currents generated by the armature of a dynamo when their direction has been regulated by the commutator; *commuted.*

Commutating Pole.—An electromagnetic bar inserted between the pole pieces of a dynamo to offset the cross magnetization of the armature currents; also called, *interpole*, or *compensating pole.*

Commutation.—The assembling of various electric currents into a uniform direction of flow.

Commutator.—1. In general, a contrivance for reversing the directions of electric currents in any circuit.

2. Specifically, the commutator of a dynamo consists of copper bars or segments arranged side by side forming a cylinder; and insulated from each other by sheets of mica. It is mounted upon the shaft near the armature and rotates with it. The conductors of the armature are so connected with the segments of the commutator that the current taken off by the brushes which bear upon the surface of the commutator are direct, although the armature generates an alternating current.

Commutator Bars.—The insulated metallic sections which combine to make up the commutator of a dynamo, upon which the brushes rest; *commutator segments.*

Commutator Coils.—Special coils wound upon the core of an armature to prevent sparking, connected at one end with the principal winding, and at the other to the commutator bars.

Commutator Flats.—A lowering in level caused by wear of the metallic segments of a commutator. It is generally caused by sparking set up by periodic springing in the armature mounting.

Commutator Lug.—A prolongation of a commutator segment at the back for the purpose of securing the leads from the armature.

Commutator Motor.—A motor, driven by alternating currents, carrying a commutator upon its armature.

Commutator of Dynamo.—That portion of a dynamo which serves to collect the electromotive forces, or currents, generated by the rotation of the armature, and deliver them with uniform flow to the outside circuit.

Commutator Press Button.—A telephone calling device whereby a subscriber may summon the central station by pressing a button, and so reversing a battery.

Commutator Segments.—The copper bars which are laid together so as to form

the cylindrical surface of a dynamo or motor commutator; *commutator bars.*

Commuted.—Acted upon by a commutator for regulating the direction of the electric currents generated in the armature of a dynamo.

Commuted Currents.—Such electric currents, generated in a dynamo armature, as have been assembled into a uniform direction by the action of a commutator.

Commuted Magneto Generator.—An electric generator sustained by a permanent magnet, having its currents commuted.

Commuting Transformer.—A *rotary transformer.*

Comparator.—An instrument by means of which an alternating current ammeter or voltmeter may be calibrated with the direct current standard. It is essentially a hot wire instrument which indicates zero when the alternating and direct currents to be compared are equal.

Compartment Manhole.—A manhole with compartments to accommodate various sections of cable.

Compass.—The *magnetic compass* consists of a magnetic needle pivoted on a fine point within a suitable case; below the needle is placed a card graduated to degrees and the cardinal points, so that the movements of the needle, which lies N. and S., always indicate the bearing of any object. The *mariner's compass* consists of a skeleton card mounted *upon* the needles, two or four parallel magnets being employed. There are two graduated circles, the inner showing the 32 points, halves and quarters, the outer graduated to 360°. The N. and S. diameter of the cards is parallel with the needles, the N. point being indicated by a *fleur-de-lis;* a black line (the *lubber's line*) is drawn vertically on the case in line with the vessel's keel, so as to show the direction of her head. The compass is mounted on *gimbals,* to preserve its horizontal position, the whole being mounted upon a *binnacle,* containing provision for counteracting *deviation.* A *spirit compass* is filled with a mixture of 1 alcohol, 2 water, within which the card floats, and is hermetically sealed.

Compass Card.—A circular disc in the mariner's compass divided into 32 degrees or points; four of these are called cardinal points, *viz.,* north, south, east and west; and four are called intercardinal points midway between the cardinal points; and these are again twice subdivided.

Compass Needle.—The polarized bar which is suspended so as to assume a direction resulting from the earth's magnetism.

Compensated Alternator.—An alternator for maintaining a uniform pressure in the circuit under different loads, having field magnets excited both by currents from a separate generator and by those furnished by the armature.

Compensated Condenser.—In duplex telegraphy, a condenser used to equalize the static capacity of the "artificial" wire and that of the main wire.

Compensated Excitation.—The excitation of an alternator both by a separate generator and by its own main circuit.

Compensated Galvanometer.—A differential galvanometer adjusted to measure the strength of the current at some remote part of a direct current circuit; one of its coils being shunt wound and one series wound with respect to that circuit.

Compensated Meter Bridge.—A slide meter bridge, so adjusted as to counteract the influence upon it of changes in temperature.

Compensated Pendulum.—A pendulum fitted with some form of device to counteract the difference in length caused by expansion. In one form, the *bob* is suspended by a framework of iron and brass rods, the upward expansion of the brass compensating the lower effect of the iron; in another, the bob or weight consists of a tube containing mercury, the upward elongation of the mercury counteracting the lengthening of the pendulum. In colder weather the downward movement of the brass or mercury balances the shortening of the rod.

Compensated Resistance Coil.—A resistance coil, so adjusted as to overcome the effects of the differences of temperature.

Compensated Voltmeter.—A station voltmeter so connected with the bus bars as to admit of automatic adjustment to any loss of pressure in any of its feeders, thus indicating the actual pressure furnished the main circuit.

Compensated Wattmeter.—An indicating wattmeter in which the error caused by the absorbing of power in its series and potential windings is corrected by the introduction of a compensating coil connected in series with the potential coil.

Compensating Coils.—1. Extra coils wound upon field magnets in series with the armature coils for the purpose of maintaining a constant pressure.

2. A name sometimes given to the series coils in a compound wound dynamo.

Compensating Cylinder.—An equalizing device, found on some high duty pumping engines, attached in pairs to each piston rod. It is an oscillating cylinder, closed at one end, within which works a plunger jointed to the main rod. On the pump starting from the end of its stroke the plungers are driven into the compensating cylinders, forcing the contained water or oil through the hollow trunnions into an accumulator or *intensifier*, the cylinder swinging on its trunnions as the stroke advances. When the pump has passed half stroke and steam is cut off by the valves, the compensating cylinders assist to drive the piston on its way, thus restoring the energy delivered into the accumulator at the beginning of the stroke. The whole serves as a reservoir of energy, comparable to a flywheel.

Compensating Line.—In duplex telegraphy, the *artificial* or *false* line, as distinguished from the main line.

Compensating Magnet.—A magnet employed to exert upon any indicating magnetic needle such a force as to overcome the effect of the attraction of the earth upon that needle.

Compensating Pole.—An electromagnetic bar or coil inserted between the pole pieces of a dynamo to offset the cross magnetization of the armature currents; also called, *interpole* or *commutating* pole.

Compensating Resistance.—A second resistance sometimes introduced in connection with a galvanometer shunt, in delicate measurements, to compensate for the reduction of resistance occasioned by the shunt.

Compensating Winding.—A winding designed to neutralize the armature cross-field, wound in series with the armature through holes in the tips of the pole pieces of a dynamo.

Compensating Wire.—In duplex telegraphy, the *artificial* or *false* line.

Compensation.—That which makes good the loss or want of something. In mechanics, that which creates a balance of forces, or acts as a counteractive of opposing tendencies.

Compensator.—A name sometimes given to the auto-transformer which is a single coil transformer, in which the same winding will serve both as a primary and as a secondary.

Compensator for Alternating Current Lamps.—A small choking coil in the circuit to reduce the pressure at the lamp terminals.

Compensator Potential Regulator.—One in which a number of turns of one of the coils are adjustable.

Compensator System.—The distribution of high pressure alternating currents to low pressure receptive devices through choking coils connected with the mains.

Complement.—Something that fills up or completes any number, quantity, word, or other thing which lacks completeness.

Complete Combustion.—Combustion in which all the elements contained in fuel, or in gaseous charges, enter fully into chemical combination with the air. In chemical language, their atoms are fully satisfied. The regulation of the fuel and air supply of furnaces should, for economical reasons, approximate as nearly as possible to these conditions.

Completed Circuit.—An electric circuit that has been *made* or *closed*; also called, *closed circuit*.

Complete Fault.—A defect which causes a complete break or interruption in an electric circuit.

Complete Wave.—A full alternation of an alternating current, conceived as rising from zero to its greatest value in one direction, returning, and reaching its greatest value in the other, and then back to the starting point; a cycle of alternation.

Completing a Circuit.—Causing a circuit to be *closed*, or *made*.

Complex Distribution of Lamellar Magnetism.—A distribution of magnetism into complex magnetic shells.

Complex Harmonic Currents.—Currents produced by the association of higher harmonic currents with the simple harmonic current.

Complex Harmonic Electromotive Forces.—Electromotive forces which re-

sult from the existence of higher harmonics in conjunction with the fundamental E. M. F. in alternating currents.

Complex Harmonic Motion.—The resultant of the combined action of simple harmonic motions.

Complex Magnetic Shell.—A magnetic shell with varying magnetic strength in different parts of its faces.

Component.—In mechanics, one of the parts of a stress or strain, out of which the whole may be compounded by the principle of the parallelogram of forces.

Component Currents.—The several currents into which a single current may be supposed to be separated, so that, acting together, they would give the precise effect of a single current.

Component Electromotive Forces.—The separate E. M. Fs. into which any electromotive force may be divided.

Component Inductions.—The distinct inductions into which any magnetic flow might be conceived to be separated, and still preserve its original effect.

Components of Impedance.—The element of actual resistance and the element of apparent resistance which are present in the opposition offered to the flow of the current.

Composite Balance.—An electric balance provided with both coarse and fine coils of wire for measuring either strong or weak currents.

Composite Grid.—A form of grid of a storage battery composed of graphite covered lead foil layers between lead plates secured with lead rivets.

Composite Wire.—A compound bi-metallic wire used in telegraph and telephone lines to secure both strength and conductivity; it consists of a core of iron or steel covered with a sheathing of copper; now superseded in best practice by hard drawn copper wire.

Composition of Forces.—In physics, the finding of a single force, called the *resultant*, which is equal to two or more given forces acting in given directions.

Compound.—Composed of two or more elements or parts; produced by the union of several ingredients, parts or things.

Compound Alternator.—A compound-wound alternator.

Compound Arc.—A voltaic arc bridging several electrodes.

Compound Cable.—A cable having a core made up of several wires stranded, or otherwise bound together.

Compound Compression.—The operation of compressing air, ammonia or other gases in two stages, successive pressure being applied at each stage, the size of the compressor cylinders being correspondingly reduced. This gradual process overcomes much of the loss occasioned by super heating of the cylinders and facilitates the attainment of high pressure.

Compound Condenser.—A condenser made up of several sections or subdivisions.

Compound Engine.—A steam engine in which the steam is expanded in two stages, thus reducing the range of temperature in the cylinders, and making the turning effort more uniform. The cylinder of the first stage of expansion is termed a *high pressure cylinder*, the larger or second one the *low pressure*. Sometimes a compound engine has three cylinders; one *high pressure* exhausting into two *low pressure* cylinders. This type should not be confounded with a three cylinder *triple expansion* engine in which the steam passes from the *high* to the *intermediate*, thence to the *low pressure* cylinder.

Compound Gauge.—A pressure gauge registering pressures above and below that of the atmosphere, or *pressure* and *vacuum*. The needle points at 0 lbs. when the gauge is in equilibrium, the movement to one side showing the deficiency below atmospheric pressure (usually in inches of mercury), the motion to the other side indicating pressure above atmospheric (usually in lbs. per sq. in.). A compound gauge is often fitted to the low-pressure receivers of compound steam engines, or to the suction connections of pumps.

Compounding.—In engineering, combining a high pressure cylinder with a low pressure cylinder, thus forming a unit capable of working with higher steam pressure and a greater range of expansion.

Compound Magnet.—A magnet made up of a group of single magnets parallel to one another with their similar poles together. A compound magnet is stronger in propor-

tion to its bulk and weight than a single magnet.

Compound Oils.—In lubrication, the advantage of a compound oil is believed to consist in this, that certain advantages of single oils are gained and their disadvantages neutralized; thus, an *animal oil* alone is liable to develope acid, to the consequent corrosion of the bearings with which it is in contact; a *vegetable oil* alone is apt to dry and gum or become sticky and clog the bearing; a *mineral oil* alone is usually thin, has a low firing point and is liable to become squeezed out and evaporated. But by a combination of the three, the body of the animal oil is retained while its tendency to decomposition is lessened, and the good lubricating property of the vegetable is utilized without much gumming taking place.

Compound Radical.—A group of atoms of matter which remains undecomposed throughout a series of chemical changes undergone by the molecules of which it forms a part.

Compound Receiver.—A telephone receiver consisting of two distinct receivers combined in a single shell, employed by a central station operator to secure a circuit independent of the speaking circuit.

Compound Winding.—A method of winding a dynamo or motor field magnet with two sets of coils, one of which is connected in series and the other in parallel with the armature and outside circuit.

Compound Wire.—A bi-metallic wire consisting of a core of iron or steel covered with a sheathing of copper, sometimes used in telegraph lines for securing both strength and conductivity.

Compound Wound.—Wound with both series and shunt coils.

Compound Wound Alternator.—An alternator having compound wound field magnets.

Compound Wound Continuous Current Dynamo.—A continuous current dynamo having compound wound field magnets in order to preserve a constant current, or current of uniform strength, through the external circuit.

Compound Wound Field.—A magnetic field with compound wound coils.

Compound Wound Motor.—A motor having compound field magnet windings in order to secure uniform speed under varying loads.

Compressed Air.—Atmospheric air compressed by mechanical means into a state of increased density. The air is often compressed by pumps at a central station whence it is led in pipes to the spot where the power is required. It may also be transported in steel tanks of convenient dimensions. The power stored in the air is given up on expansion within a cylinder, where it drives a piston in the same manner as steam. Compressed air is employed to drive drills, riveting and chipping machines; many varieties of portable tools: hoists and pumps; small scattered engines or auxiliary machines for various purposes.

Compressibility of Gases.—Owing to the perfect freedom of motion among the molecules of a gas, it is possible to compress gases to a very great extent, reducing a given volume to much less than its normal bulk. The pressure at constant temperature varies in inverse ratio to the volume, according to *Boyle's Law.*

Compressibility of Liquids.—As with gases, liquids can offer no resistance to change of shape, only to change of volume. Their resistance to change of volume is very great indeed, and can only be ascertained by delicate experiments; a pressure of one atmosphere will compress a volume of water about .0000466 of its bulk, and a volume of alcohol only .0000216. This is so slight that it may be neglected in engineering.

Compressibility of Solids.—This varies greatly; with metals and many elementary substances it is so small as to be neglected in engineering, but with highly complex substances, especially those of organic origin, it is often very large; as, for instance, with most woods, cork, india rubber, etc.

Compression.—1. In physics, the reduction in length, area, or volume of a body, which is occasioned by the application of external force or pressure.

2. In steam engineering, to press together or into smaller space; reduce in volume; as, steam behind the piston on the exhaust stroke, after *exhaust closure.*

Concave.—Depressed or indented with curved outlines; a surface which is part of the interior of a hollow sphere; opposed to *convex.*

Concealed Wiring.—Indoor wiring, either run inside the walls or otherwise not exposed to view.

Concentrated Load.—In mechanics, a localized load or stress bearing upon one particular point of a beam or similar structure. Other things being equal, a *concentrated load* has twice the effect of a *distributed load.*

Concentration of Lines of Force.—The intensifying of the strength of magnetic flow.

Concentration Throw.—The deflection of a magnetic needle when exposed to a current generated by metal plates subjected to chemical action within a magnetic field.

Concentric Cable.—A cable consisting of a heavily insulated core acting as a leading conductor, and an enveloping metallic tube acting as a return conductor.

Concentric Carbon.—An arc lamp carbon having an inner core of charcoal or of a softer grade of carbon than the outside, also known as cored carbon; it is used in a modification of the "Jablochkoff candle."

Concentric Conductor —A tubular conductor containing an inner conducting core separated from it by insulation.

Concentric Cylindrical Carbon.—Arc light carbons composed of a carbon rod within a hollow carbon cylinder, and insulated from it by an air space or by interposed non-conducting material.

Concentric Mains.—Main conductors consisting of concentric cables.

Concentric Wiring.—Wiring with concentric cables.

Concrete.—A mixture of Portland cement, sand and some coarse material, such as gravel, broken stone, etc.; much used for foundations, heavy masonry and engineering structures generally. Moulds or *forms* are constructed of timber to the desired outlines, and the concrete, being mixed with water, is placed within the mould until it is full, when, after a proper interval for *setting* or drying, the boards of the form are removed, leaving the structure a solid.

Concrete Blocks.—Blocks made of concrete and used in the construction of buildings, breakwaters, etc. They are made by mixing cement, sand and stone, wet or dry, and depositing this mixture in forms; called also, *artificial stone.*

Condensance.—The reactance in an electric circuit due to capacity acting in the opposite direction to the reactance of the inductance.

Condensation.—Reduction in bulk of any substance accompanied by increase in density. Specifically applied to the transformation of heated vapor into liquid by contact with a cold body; as, the condensation of exhaust steam in an engine.

Condenser.—1. An accumulator of electrical energy. A Leyden jar is a simple form of condenser. In practice it usually consists of layers of tin foil insulated from each other by sheets of paraffined paper, oiled silk, mica, etc., sealed in an air tight case. It is an important apparatus in telegraphy and telephony.

2. In steam engineering, an apparatus in which the exhaust steam is reconverted into water, either by mingling with a spray of cooling water, or by contact with cooled surfaces. The first process is termed *jet condensation;* the second, *surface condensation.*

Condenser Capacity.—The quantity of electricity a condenser is capable of containing.

Condenser Circuit.—An electric circuit having a condenser included in it.

Condenser Lightning Arrester.—A lightning arrester operating through a condenser placed in the circuit for that purpose.

Condenser Pressure.—The electrical pressure between the terminals of a condenser in phase with the condenser current; the capacity pressure.

Condenser Rheostat.—In duplex or quadruplex telegraphy, a rheostat connected with a condenser in the *false* or *artificial* line.

Condenser Signaling.—The use of a condenser in telegraph or telephone service.

Condensing Electroscope.—A form of gold leaf electroscope invented by Volta, in which the condensing power of two prepared discs is used to aid in the detection of very feeble electric charges.

Condensing Engine.—A steam engine in which the exhaust steam is condensed instead of being discharged into the air.

Conditioning.—A term with varied applications in the arts; especially:

1. The act or process of testing to ascertain the quality or condition of materials.

2. To bring to a proper state or condition for certain processes of manufacture.

Conduct.—1. The act or method of conducting; guidance; that which carries or guides anything.

2. To permit the passage of an electric current.

Conductance.—That quality of a given conductor in virtue of which it facilitates the flow of an electric current; it is the opposite of resistance, and is measured in terms of the *mho.* Conductance varies directly as the area of the cross section and inversely as the length. Heat decreases the conducting power of elementary substances. Carbon is an exception, being a better conductor at a red or white heat than when cold. At low temperatures the conducting power of metals is improved.

Conductance Leak.—A leak occasioned in a circuit as a result of conduction, as opposed to one produced by induction.

Conductibility.—Having the capacity of conducting an electric current.

Conducting Cord.—A slender rope made up of insulated strands of wire, for the purpose of conducting a current of electricity.

Conducting Loop.—A loop of any conducting material.

Conducting Power.—1. The capability of a substance to conduct electricity, considered in comparison with the conducting power of pure copper taken as a standard.

2. The power which a substance has of conducting heat through its mass; thermal conductivity.

3. The susceptibility of a substance to allow the free action of magnetic force through it; sometimes called magnetic transparency.

Conducting Surfaces.—Those surfaces of a steam generator which are directly arranged for the transmission of heat; as, the heating surface of a boiler which is a *conducting surface.*

Conducting Tip.—A tip of conducting material adjusted to the end of a wire so that it may be readily fitted into a socket or binding post.

Conduction.—1. The flow of an electric current through a conducting body, such as a metallic wire.

2. The transfer of heat from the hotter to the colder parts of a body. Hence, conduction depends upon the fact of inequality in temperature existing in the several portions of a body. The transfer of heat through solids; as, through boiler plates, is due to *conduction.*

Conduction Current.—An electric current traversing conducting material, such as metals, as opposed to a current which may be present in a non-conductor.

Conduction Lightning Protector.—A device for protecting electrical instruments against the effects of lightning discharges.

Conduction of Heat.—The transfer of heat through substances, from one substance to another in contact with it. Any body which transmits heat rapidly is called a good conductor of heat; one that passes heat slowly is termed a bad conductor. Homogeneous bodies such as metals are the best conductors; those which are finely fibered such as cotton, wool or wadding; or those finely subdivided as charcoal dust or pulverized cork, are the worst conductors of heat. A bad conductor is also known as a *non-conductor.*

Conduction Resistance.—The resistance which an electric conductor offers to the flow of a current.

Conductive.—Having the capability of conducting electricity.

Conductive Discharge.—A discharge of electricity from a charged body, by bringing a conducting substance into contact with it; as distinguished from *disruptive* discharge.

Conductivity.—1. The specific electric conductance of a substance, the relative power of carrying the electric current possessed by different substances, the conducting power of pure copper being taken as the standard. Sir William Thomson has suggested as the unit of conductivity, the *mho,* or *ohm* written backwards, the reciprocal of the ohm.

2. The relative value of a material, as compared with a standard, in affording a passage for the transmission of an electric current.

Conductivity Resistance.—The opposition which a substance makes to the flow of electricity.

Conductor.—A substance which is capable of being a medium for the transmission of an electric current, especially one which conducts electricity with great ease.

Conductor Resistance.—Resistance offered to an electric current by the wires through which the current is transmitted.

Conductor System.—A system of interlacing electric conductors for the distribution of electricity.

Conduit.—1. A passageway for underground cables and conductors, built up of single or multiple-duct sections of vitrified clay, cement or iron, laid in concrete, forming a continuous system of protective tubing from manhole to manhole.

2. In street railway systems, the pit between the rails in which is run either the cable of a cable railway, or the live supply wire of an underground trolley system.

3. A pipe or passage, usually covered, for conducting water under dams, railroad beds, etc.

Conduit Cables.—Cables for conducting electricity placed underground in a system of conduits.

Conduit Conductors.—Insulated conductors for distributing electricity in underground circuits.

Conduit Trolley System.—An underground trolley system in which the wire is run in an underground conduit midway between the rails of the track, the connection with the motor being effected by means of a shoe introduced through a slot.

Cone.—In geometry, a solid figure described by the rotation of a right angle triangle upon one of its sides as an axis, or one which tapers uniformly from a circular base to a point.

Coned Plunger.—A solenoid core made thicker midway between the ends, instead of having the usual cylindrical shape, for the purpose of obtaining a more uniform pull in different portions of the coil.

Cone Valve.—A hollow valve having a conical, perforated face, through which water is discharged when the valve rises, without impinging directly upon the valve face or seat.

Conical Conductor.—A conductor of conical shape, tapering at the ends, used for obtaining a constant density of the current in a parallel system of electrical distribution.

Conjugate.—1. United in pairs; yoked together; coupled.

2. In chemistry, containing two or more radicals supposed to act the part of a single one.

Conjugate Coils.—Two coils in such relation to each other, as to possess conjugate conductors; they are so placed, that the lines of force established by one do not pass through the coils of the other. With this arrangement, variations of current may take place in one without inducing currents in the other.

Conjugate Conductors.—Two conductors so related to each other that the presence of electro-motive forces in one produces no effect on the other, and variations of the current in one result in no induced currents in the other.

Conjunction.—The act of conjoining, or the state of being conjoined, united, or associated; union.

Connect.—To make an electrical connection, by bringing one electric conductor into contact with another.

Connecting Bars.—In a telephone multiple switchboard, metal bars for connecting the operator's set with the call wire spring jacks.

Connecting Box.—In underground wiring, a metallic box in which junctions are made between feeders and mains, or between mains and supply wires.

Connecting Jack.—The terminals of a line entering a telephone exchange; it consists of a socket containing a simple switching device, mounted on the face of a switchboard, into which the connecting plug is to be inserted.

Connecting Peg.—A piece of metal for filling an air space in any apparatus, in order to make an electrical connection across that space; a plug.

Connecting Screws.—Binding posts, or similar devices, for securing conductors at the point of electrical contact.

Connecting Side.—The side of a telephone switchboard on which the operator makes the connections with the subscribers called for.

Connecting Sleeve.—A device, usually provided with binding screws, for holding

in contact the ends of wires brought into electrical connection.

Connecting Up.—The act of completing an electrical connection.

Connection.—A finished electrical contact.

Connection Board of Transformer.—A board within a transformer, having binding posts, by means of which connections are made between outside circuits and the transforming coils.

Connector.—Any device for holding in electrical contact the ends of conducting wires in such a manner that they may readily be released when it is desired to disconnect them again.

Consecutive.—Following in a train; succeeding one another in a regular order; successive; uninterrupted in course or succession.

Consequent Points.—The points upon a magnet at which consequent poles may develop.

Consequent Poles.—1. Magnetic poles occurring abnormally at some point along the axis of a magnetized bar which has its regular poles at the ends; secondary or resultant poles.

2. Magnetic poles developed on a dynamo when the direction of the current flowing in the magnetizing coils is such as to produce two similar poles in each pole piece.

3. Poles occurring in a dynamo at points elsewhere than at the pole pieces.

Conservation of Electricity.—A term proposed by Lippman for the theory that: every charge of electricity has an opposite and equal charge somewhere in the universe more or less distributed; that is, the sum of positive charges is always equal to the sum of negative charges.

Conservation of Energy.—The doctrine of *physics*, that energy can be transmitted from one body to another or transformed in its manifestations, but may neither be created nor destroyed. Energy may be dissipated, that is, converted into a form from which it cannot be recovered, as is the case with the great percentage of heat escaping with the exhaust of a locomotive or the circulating water of a steamship, but the total amount of energy in the universe, it is argued, remains constant and invariable.

Consonance.—1. A sounding together; the reinforcing of sound by a body set in vibration by the first sounding body.

2. In a transformer circuit, a relation between the primary and secondary, due to mutual induction, such that the apparent reactance of the primary circuit is zero.

Consonator.—A body which has the capacity for consonance with a sounding body.

Constant.—1. A quantity or magnitude, derived from actual experiment, which is included as a factor in most formulas for the purpose of bringing theoretical calculations in agreement with experience.

2. The calculated value of certain invariable factors to facilitate computation. Thus, a marine engineer will calculate out for each cylinder, area of piston in square inches × twice stroke in feet ÷ 33,000; and then to obtain the indicated horse power at any time, all that is necessary is to multiply this *constant* by the mean pressure from the indicator card and the revolutions per minute.

Constant Cell.—A voltaic cell of such a character as to furnish a constant electric current.

Constant Current.—An electric current of continuous and uniform strength which preserves a uniform direction in its course; an unvarying current.

Constant Current Arc Lamp.—An arc lamp used in series connection in a constant current circuit.

Constant Current Circuit.—A circuit preserving throughout a uniform strength of current under varying resistance conditions.

Constant Current Dynamo.—A dynamo designed to supply a constant current strength to the circuit under varying loads.

Constant Current Transformer.—A transformer which sustains a constant current in its secondary circuit under varying loads.

Constant Inductance.—Inductance not affected by changes in the strength of the current.

Constant Potential Alternator.—An alternator which maintains a constant potential difference at the dynamo terminals under variations of resistance.

Constant Potential Arc Lamp.—An arc lamp maintained in an incandescent

system in which a constant potential difference is preserved between the leads.

Constant Potential Circuit.—A circuit preserving a constant potential difference; as, a parallel circuit.

Constant Potential Dynamo.—A compound wound dynamo designed to maintain a constant potential difference at its terminals under variations of resistance.

Constant Potential Motor.—A shunt motor. The fields being connected directly across the line exert a constant magnetic force.

Constant Resistance.—A resistance of known value, fixed and unchanging.

Constant Speed Motor.—A motor, such as the synchronous motor, the induction motor, and the direct current shunt motor, in which the speed is constant or nearly so.

Constituent.—One of the parts or ingredients which go to form any particular whole; an elemental portion of a compound.

Constrict.—To draw together; to render narrower or smaller; to bind; to cramp; to contract or cause to shrink.

Construction.—1. Building up or erecting; the erection of a structure from previously formed elements.

2. In architecture, the planning, designing and erection of a structure; the setting up of plant and all processes preparatory to active productive operation.

3. In civil engineering, the building of such public works as roads, railways and canals, as differentiated from the subsequent work of maintaining and repairing them.

4. In mathematics, the building up of a thesis or the delineation of certain figures, in accordance with previously demonstrated principles, whereby the solution of a problem may be attained or some theorem demonstrated to be correct; this is especially applied in *geometry*.

Construction Engineer.—An engineer responsible for constructive work; the term is applied especially to a civil engineer, subordinate to the chief engineer of a railway, but who is in charge of all new works for the line, as against the other department having responsibility for *maintenance* of existing structures and works.

Construction Way.—In civil engineering, as distinguished from the finished or permanent way of a railroad. It is a temporary way used in transporting gravel, timber, rails, or transporting and obtaining earth, etc., from other points where the cuttings for the track do not furnish it. It generally keeps its name until the main road is in running order and opened for the public service.

Consulting Engineer.—An engineer, civil, mechanical or electrical, generally of high standing and long experience, who acts as an expert, giving advice to non-technical firms, public authorities or private individuals with regard to technical matters. Often, the services of a consulting engineer include responsibility for the whole of the conduct of the engineering side of a business, especially with steamships, electric installations, etc.

Consumer.—A person to whom electricity is supplied.

Consumer's Terminals.—The terminals in a consumer's house, at which electricity is delivered for his use.

Consumption Circuit.—An electrical circuit, the current of which is consumed or used up by electro-receptive apparatus placed within it.

Contact.—1. The act of touching. The relation of superposed surfaces to each other, the extent of their coincidence being the measure of the perfection or otherwise of the contact.

2. Two or more surfaces abutting on each other in such manner as to close an electric circuit; as, in make and break or low tension ignition.

Contact Breaker.—1. A contrivance for quickly and automatically breaking or making an electrical circuit normally existing between two contacts.

2. In gas engine ignition, a device to open or break the electric circuit, at the proper time for the production of a secondary spark across the air gap of the spark plug. Used instead of a *contact maker*, with engines running at unusually high speeds. The closed circuit, working, allows more time for the magnetic flux in the coil core to attain a density sufficient to produce a *good spark*.

Contact Electricity.—Very small charges of electricity generated by the contact of two insulated pieces of dissimilar metals.

Contact Electric Railway.—A type of electric railway, employed in industrial works, obtaining current for the motor through contact buttons embedded in the track structure, thus doing away with dangerous conductors.

Contact Electromotive Force.—Electromotive force arising from the difference of potential between two dissimilar metals when in contact with each other.

Contact Faults.—A term applied to faults due to conductors coming into contact with each other; *a short circuit.*

Contact Lamp.—A form of electric lamp which produces a kind of incandescence with an incipient arc, from the loose contact of two carbon electrodes; also called semi-incandescent lamp.

Contactors.—In the multiple-unit system of electric railway control, the devices which serve to operate the various resistances, to make and break the main circuit between trolley and motors, and to change from series to parallel connection. They consist of movable arms tipped with copper for making contact with a corresponding fixed copper tip when actuated by current by the master controller.

Contact Points.—In ignition, the metal points by which contact is made for completing the circuit in igniters, contact makers, vibrators of induction coils, etc.

Contact Resistance.—The resistance due to the lack of absolute contact between two connecting surfaces in a circuit.

Contact Ring of Telephone Switchboard.—A test ring in a multiple telephone switchboard which makes a contact with the sleeve of the spring jack plug for the "busy test."

Contact Rings of Alternator.—Collecting rings in contact with the armature of an alternator.

Contacts.—1. Metal pieces set at different points in an electrical circuit for conveniently making and breaking the circuit.

2. Faults arising as a result of contacts occurring between an electrical circuit and some external conducting substances.

3. The creation of a disturbance in a circuit by the accidental touch of another circuit.

4. In ignition, the stationary insulated metal segments forming part of a *timer*, there being one for each cylinder of the engine. During one revolution of the *rotor* of the timer, the primary circuit is made and broken once for each cylinder, thus firing the several charges in proper order.

Contact Screw.—A screw furnished at its end with a metal contact for closing a circuit.

Contact Series.—An arrangement of metals in a series such that each metal receives positive electricity by the contact with the one next following.

Contact Theory.—A theory attributing the source of electricity to the mere contact of dissimilar bodies.

Contact Theory of Voltaic Cell.—The contact theory applied to account for the action of a voltaic cell.

Containing Cell.—1. The vessel which contains the voltaic couple and associated electrolytes which combine to make up a voltaic cell.

2. Any jar for holding solutions employed in electrical work.

Continental Telegraph Code.—The telegraph code used in Europe as distinguished from the American Morse code. Its chief distinction is that the spaces employed in the American code are excluded in the Continental.

Continuity of Circuit.—The state of a circuit which preserves an unbroken course throughout for the flow of electricity.

Continuity Preserving Transmitter.—A transmitter in duplex telegraphy which permits the transfer of the line wire from the battery to the ground without interrupting the circuit.

Continuous.—Without break, cessation or interruption; without intervening space or time; uninterrupted; unbroken.

Continuous Alternating Transformer.—A transformer for changing a continuous to an alternating current, or *vice versa*, such as a *rotary transformer*.

Continuous Current.—A steady, or non-pulsating, direct current; one that has a uniform and constant direction of flow, as opposed to an alternating current.

Continuous Current Arc.—A voltaic arc produced by means of a direct instead of an alternating current.

Continuous Current Armature Windings.—Armature windings designed to create continuous currents.

Continuous Current Motor.—A motor driven by a continuous current.

Continuous Current Transformer.—A motor generator, or dynamotor, for changing the potential difference in an electric circuit.

Continuous Electromotive Forces.—Electromotive forces of uniform direction and unvarying value.

Continuously Insulated Cable.—A cable running between two given points without having its insulation cut for the introduction of tap wires.

Continuous Ringing Bell.—An electric bell which continues to ring after the contact is made till some one stops it.

Continuous Spectrum.—A spectrum of light showing every shade of color, from the extreme red at one end to the extreme violet at the other; such spectra are to be obtained from the electric light, lime light, and all solids or liquids heated to incandescence.

Continuous Surface Commutator.—The collector ring used on alternating current motors or generators is a complete circle of copper and presents a continuously smooth surface to the contact of the brushes.

Continuous Trolley Wire.—A trolley wire in a single length, instead of being made up of a number of lengths joined together.

Continuous Winding.—A term sometimes applied to wave winding.

Continuous Wire.—A wire free from joints.

Contour.—1. The outline of a figure or a body; the line that bounds; periphery.

2. In civil engineering, the form of the ground surface with respect to its undulations.

3. In surveying, a horizontal plane intersecting a portion of ground.

Contracting Magnetic Whirls.—Magnetic whirls which tend to contract in the direction of the electromagnet from which they spring.

Contraction.—The act or process of shortening, or shrinking; the state of being contracted; as, the *contraction* produced by cold; in mathematics, the process of shortening an operation; in a foundry, the reduction in size of a casting from the time it is poured until it cools.

Contraction Fit.—In machine shop work, a fit employed when a bore requires to be firmly and permanently fastened to a cylindrical piece, as a shaft. The bore is turned to a smaller diameter than the cylindrical piece, then heated so as to expand the bore; the cylindrical piece is then inserted and the cooling of the bore causes it to contract upon the cylindrical piece with a force varying with the amount allowed for contraction; also called a *shrinkage fit.*

Contraction of Area.—The amount by which the area, at the point where a test piece has broken, is reduced below what it was before any strain or pulling force was applied. The contraction is usually expressed as a percentage, and is an indication of the ductility of the material tested.

Contraction Rule.—In pattern making, a rule in which the various divisions are made longer than the actual measurement by an amount proportionate to that which the casting contracts in passing from a molten to a solid state. Generally taken as $\frac{1}{16}$ inch to the foot in cast iron and $\frac{3}{16}$ inch per foot for brass. Also known as *shrink rule.*

Contractor.—An individual or firm who, by a legal agreement, undertakes to execute certain work for a stated remuneration; as, a firm of electrical engineers.

Contracture.—A state of rigidity of the muscles of the body sometimes resulting from the shock of an electric current.

Contraplex Telegraphy.—Transmitting telegraphic messages simultaneously along the same wire in *opposite* directions, as distinguished from *diplex* telegraphy.

Controlled Clock.—An electric clock having its movements governed by a master clock.

Controller.—1. A magnetic device for the automatic regulation and control of an electric current.

2. The switch by means of which the motorman of a trolley car governs its movements. It consists usually of a vertical cylinder containing contact points pressing against flat springs, and is operated by turning a handle at the top: a car controller.

3. A device attached to electrically propelled vehicles, consisting of a number of switches and contacts disposed spirally about a vertical spindle or rod. By moving this spindle through different

angles, the motors may be run in parallel for starting, in series for continued running, the current may be shut off, or the motors reversed, while other positions regulate the resistance and so increase or decrease the running speed.

Controller Points.—Short radial bars or "points" cast upon the cover plate of a street railway controller for the purpose of indicating to the motorman the position of the handle in relation to the contacts within the casing.

Controller Resistance.—Resistance introduced in trolley car controllers for governing the movement of the car.

Controller Switch.—The switch which operates the controller of a trolley car.

Controlling Box.—A box or case containing a controller.

Controlling Clock.—In a system of electric time keeping, the master clock by which the movements of the secondary clocks are controlled.

Controlling Desk.—A marble or steel desk, or bench board built to enclose a concentration of controlling apparatus.

Controlling Field.—In galvanometers, the magnetic field used to bring the needle back to a definite position whenever it is turned.

Controlling Magnet.—A magnet employed to exert a controlling influence upon any action; as, for example, the automatic controller for the regulation of constant currents.

Controlling Stand.—A stand provided to support the controlling mechanism of a motor.

Convection.—The flow of electricity by the motion of charged particles of air passing off in currents from a pointed electrified conductor.

Convection Currents.—Currents arising from the motion of charged particles thrown off in electrified streams called convection streams.

Convection of Heat.—1. The effect produced by an electric current upon the temperature of an unevenly heated wire.

2. The transfer of heat by the motion of the heated matter itself; it can, therefore, take place only in liquids and gases.

Convection Streams.—The flowing of charged air particles in streams from a pointed end of a highly electrified conductor; sometimes called electric wind.

Convection Transference.—Electrical transference taking place through the medium of convection streams.

Convective Discharge.—A discharge of static electricity which takes place through the air in convection streams from a pointed conductor, or through rarefied gas with luminous effects between electrodes; a quiet or silent discharge as distinguished from a *disruptive* discharge.

Conventional.—1. Arbitrary; established by custom or general usage.

2. Dependent upon accepted models or traditions for a formal representation instead of an actual copy of nature; purposely deviating from natural forms for good reasons, although adhering to the principles which underlie them, as the conventional figures employed to represent condensers, batteries, etc.

Converge.—To cause to tend to one point; to cause to incline and approach nearer together.

Convergence.—Mutual approach towards each other as with two lines which are not parallel.

Converging Magnetic Flux.—Magnetic flux tending to converge towards a point.

Conversion.—The act of turning or changing from one state or condition to another; or the state of being changed; transmutation; change.

Convert.—The act of making a change in an electric current through a transformer.

Converted Currents.—Currents which have been acted on by a transformer.

Converter.—1. A machine employing mechanical rotation in changing electrical energy from one form to another. Also called, *transformer*.

2. In steel making, an egg shaped retort, mounted on trunnions, which, in the Bessemer process, is filled with molten pig iron, tilted at a suitable angle, and air blown through until the spectroscope shows the combined carbon to be burnt away. A proper proportion of spiegeleisen or ferro-manganese is added to give the proper percentage of carbon, and after a little further agitation the charge is run off to be cast into ingots.

3. In copper smelting, an apparatus similar to the above, in which sulphur, arsenic, etc., is burnt off from the *matte*.

Converter Bracket.—A bracket for supporting a transformer and its accessories in a street lighting system.

Converter Fuse.—A safety fuse set in the circuit of a transformer within the transformer box.

Converting Station.—A station operating electric transformers.

Convex.—Rising or swelling into a spherical or rounded form; bulging; said of a spherical surface or curved line when viewed from without, in opposition to *concave*, which signifies a rounded form of the *interior* surface.

Conveyer, Electric.—Any electrically propelled apparatus for carrying purposes.

Convolutions.—The loops in a coil of wire.

Cooling Box.—A small flat box in Armstrong's hydro-electric machine through which the stream passes and partly condenses before passing out at the nozzles.

Cooling Surface.—In a surface condenser, the area exposed to the steam or other vapor by the tubes, etc., cooled by circulating water. If the vapor be *outside* the tubes, as in steam engineering practice, the cooling surface is calculated on the external diameter of the tubes; if the vapor be *inside* them as in an ammonia condenser, it is calculated on the bore of the pipes.

Cooling Surface of Armature.—That part of an armature from which the heat generated by its rotation may pass off into the air.

Cooling Tower.—An apparatus intended to dissipate the heat from the condensing water of a power plant, where the supply is limited or the value of land prohibits a cooling pond or lodge. Essentially, it consists of a tower or stack, from the top of which the heated circulating water is sprayed over a cellular construction of brushwood, earthenware pipes, wire mats, diaphragms or other *baffles*, designed to expose the water to the cooling influences of the atmosphere while in a film or fine rain, the process being assisted by the evaporation of part of its bulk. Counter air currents are maintained by side ventilation, natural draught (using the tower as a chimney), or by a fan blast. The cooled water collects in a tank or *sump* within the foundations, and its decrease by evaporation is made up from the public water mains or a well.

Cooling Tubes.—Tubes for supplying cold water to an alternating current transformer, in order to reduce the temperature.

Cooling Water.—The injection or circulating water for a condenser, with steam or other heat engines or with refrigerating plants. The necessary quantity depends upon the nature of the machinery.

Cooper-Hewitt Lamp.—The mercury vapor lamp invented by Peter Cooper-Hewitt. The mercury arc is produced in a glass tube exhausted to a low pressure. The heat of the electric current creates a vapor from a supply of mercury at one end of the tube which forms a conducting path for the current, giving out a greenish light at a high efficiency.

Co-ordinate.—1. A thing of the same rank with another thing; one of two or more persons or things of equal rank or authority.

2. Lines, or other elements of reference, by means of which the position of any point, as of a curve, is defined with respect to certain fixed lines, or planes, called *co-ordinate axes* and *co-ordinate planes*.

Copal Varnish.—A superior variety of varnish manufactured from copal, a resin derived from an African tree.

Co-periodic.—Having corresponding periodicity, as co-periodic electromotive forces.

Co-phasal.—Corresponding in phase.

Co-phasal Alternations.—Alternations corresponding in phase.

Co-phase.—Co-periodic motions identical in phase.

Copper.—A brownish red metal, tough, malleable and ductile. It can be cast, forged, rolled and drawn. Next to silver it is the best conductor of electricity and heat known, and hence is the most important conducting material in electric practice. It is used in the shape of wire, cable, ribbon, strap and bars. The conductivity of Matthiessen's pure copper at a temperature of 0° C. is usually taken as a standard; *i. e.*, 100%. It is the only metal which occurs native, abundantly in large masses; it is found also in various ores, of which the most important are *chalcopyrite*, *chalcocite*, *cuprite* and *malachite*. Copper is preeminently the metal used for electric conduction, being at once among the best conductors, the most ductile, the strongest and the cheapest; in each of these respects it is excelled by one or more of the other metals, but no other approaches it in the average of all qualities.

Copper Alloy.—An alloy containing 98.55% copper, 1.4% tin and .05% silicon, employed to manufacture a wire known commercially as *phono-electric wire.* Its conductivity is only 40% of that of pure copper, but it is much tougher and has a tensile strength 40–45% greater than hard drawn copper. It is used for trolley wire, and long telephone line spans.

Copper Arc.—A voltaic arc produced between electrodes of copper.

Copperas.—Ferrous sulphate, also known as *green vitriol* and green copperas, prepared either by the action of dilute sulphuric acid on iron, or by gently roasting iron pyrites in the air.

Copper Bath.—A bath for electroplating with copper, consisting of a solution of cyanide or acetate of copper within which one or more plates of pure copper are suspended. The anodes are these copper plates, and the cathodes, the objects to be plated hung opposite to them.

Copper Battery.—A battery used in telegraphy for sending "copper", or positive currents over the line.

Copper-carbon Brush.—A commutator brush consisting of a carbon block partly copper plated to permit the soldering of flexible cables to them, thereby improving the electrical connection between the brushes and the holders.

Copper Connector.—1. A form of connector for uniting the copper element in a gravity cell to the conductor.

2. A device employed in connecting heavy conducting wires.

Copper Damping.—A method of bringing to rest the moving parts of a galvanometer after deflection, in which the needle is enclosed in a cavity in a block of copper. When the needle moves, it sets up eddy currents in the copper, which retard the swing without effecting the final deflection.

Coppered Carbons.—Arc light, or other carbons, covered with a layer of copper deposited by electrolysis.

Coppered Plumbago.—Plumbago in a powdered state dusted with copper, used to prepare non-metallic surfaces for electroplating; as in electrotyping.

Copper Efficiency.—The electrical power available for use as supplied by a copper conductor, compared with the electrical energy originally delivered to the conductor by the generator.

Copper Gauze Brush.—A commutator brush composed of copper wire gauze, instead of a solid copper strip.

Copper Heat.—The heat generated in a copper wire when an electric current passes through it.

Copper Lead Accumulator.—A storage battery made up of copper and lead plates in a bath of sulphate of copper.

Copper Loss.—1. The actual loss of electrical energy resulting from the resistance offered to the flow of the current through a copper conductor.

2. The loss of power occurring in transformers due to losses in the windings, plus that due to eddy currents set up in the conductors themselves.

Copper Magnetic Circuit.—A magnetic circuit partially made up of copper conductors.

Copper Pipe.—In steam engineering, copper is used for the steam and various other pipes of large engines, its utility consisting in the readiness with which it can be curved to any form, and in the ease with which it accommodates itself by expansion and contraction to variations of temperature without risk of tearing off the flanges. The flanges of copper pipes are brazed on, a hole being bored through the flange to receive the pipe.

Copper Plating.—The process of depositing a coating of copper upon a metallic surface by electroplating. The object to be plated forms the cathode immersed in a solution of copper carbonate or sulphate, while the anode consists of a plate of pure copper. A good copper plating bath is made by dissolving in a gallon of water, 10 ozs. potassium cyanide, 5 ozs. copper carbonate, and 2 ozs. potassium carbonate.

Copper Pyrites.—The commonest ore of copper, a double sulphide of copper and iron, sometimes containing some arsenical sulphide in addition.

Copper Resistance.—The conductor resistance encountered in a submarine cable.

Copper Resistivity.—The specific resistance of hard drawn high conductivity commercial copper; Matthiessen's standard being .153858 standard ohms resistance for

a wire one meter long, weighing one gram at 60° F.

Copper Ribbon.—Copper conductors in the form of flat strips or ribbons; *strap copper*.

Copper Shell of Electrotype.—The thin layer of copper deposited by the process of electroplating upon the impression prepared for reproduction in electrotype.

Copper Smelting.—This is a long and elaborate process effected in reverberatory furnaces or converters. The pyrites ores are roasted to liberate arsenic, and the temperature is then raised until the metal fuses, producing *cuprous sulphide* and *silicate of iron;* this silicate is removed as slag. By repeating the roasting and fusion, all the iron is removed. (The cuprous sulphide is carefully roasted until it consists of two-thirds oxide, the temperature is then raised until it becomes copper and sulphur dioxide.) On remelting, the copper is *poled* with green wood, to reduce the oxide remaining. Much copper is refined by *electrolysis;* the blister copper is cast into slabs for anodes, which decompose under the action of an electric current of low voltage and small amperage. The electrolyte is a solution of sulphate of copper, and the pure copper is deposited on a thin *cathode plate* of pure metal.

Copper Straps.—Thin bars or flat strips of copper.

Copper Strip Winding.—A form of armature winding in which the conductors are in the form of strips of insulated copper, instead of lengths of copper wire.

Copper Sulphate.—A compound of copper, sulphur and oxygen, also known as *blue vitriol* in solution, and *bluestone* in crystals. It is used as a depolarizer in the Daniell cell, and by the action of electrolysis, sulphuric acid is derived from it.

Copper Tape.—Thin strips of copper for winding armatures.

Copper Voltmeter.—An instrument for measuring larger current values than is possible with the silver voltmeter. The anodes are of pure copper, the cathode is copper or platinum, and the electrolyte a solution of pure copper sulphate.

Copper Zinc Accumulator.—A storage battery made up of copper and zinc plates in a bath of sulphate of zinc.

Copying Telegraphy.—A method of automatic telegraphy whereby a message is received in facsimile of the transmitter's handwriting; also called, *pantelegraphy*.

Corbel.—1. In carpentry, a block of timber resting on a post, and supporting the ends of timber girders.

2. In architecture, a form of bracket used in Gothic architecture to support the ends of cornices, arches, parapets, etc. It is a projecting block of stone, usually carved and with a receding face.

3. In masonry, bricks are also said to be *corbelling* when the courses overhang each other, thus forming a continuous *projection* around the wall.

Cord.—A cord made up of a pair of flexible insulated wires for conducting electricity.

Cord Adjuster.—A simple device which makes it possible to set a pendant incandescent lamp at any desired height, by lengthening or shortening a loop in the cord passing through the adjuster.

Cord, Electric.—An insulated electric conductor made up of a number of fine wires to secure flexibility.

Cord Peg.—A connecting peg or plug attached to a flexible conducting cord for use in a telephone switchboard.

Cord Peg Connection.—A connection made in a telephone switchboard by a cord peg.

Cord Pendant.—A flexible conducting cord with a pendant incandescent lamp attached.

Cord Shelf.—A shelf in connection with a telephone switchboard for the accommodation of the cord pegs.

Core.—1. The insulated electrical conductor of a cable, as distinguished from the outer covering or sheathing.

2. The mass of iron forming the interior portion of an electromagnet, and around which the coils are wound.

3. The metallic body of a dynamo or motor armature upon which the windings are built up.

4. The bundle of iron wires upon which the primary and secondary coils of an induction coil or transformer are wound.

Cored Carbons.—Carbons for arc lamps having an inner core of soft carbon.

Core Discs.—Thin plates of sheet iron united in such a way as to form circular discs for building up the laminated cores of dynamo or motor armatures.

Coreless Armature.—A variety of armature lacking the usual iron core.

Core Losses.—The electric losses occurring in the core of an armature or transformer due to eddy currents, hysteresis, and like influences.

Core Pins of Magnet.—Pins for securely fastening the cores of an electromagnet to the yoke.

Core Ratio of Cable.—The ratio between the diameter of the core of a cable and its insulation.

Core Transformer.—A transformer having an iron core upon which the wire is wound in such a manner that the iron is enveloped within the coils, and the outer surface of the coils is exposed to the air, as distinguished from a *shell* transformer.

Core Valve.—A plug valve which has a rotary turning motion in a hollow conical seat; occupying about the same relative position to its seat, as the core of a *faucet* does to the casting itself.

Core Ventilation.—Air spaces provided in the core of a dynamo or motor armature to allow of circulation for the purpose of keeping the iron cool.

Corliss Engine.—A steam engine fitted with Corliss valves. These are usually four in number for each cylinder, a separate steam and exhaust valve being provided at each end. The valves are shaped as a sector of a cylinder and rotate within a cylindrical seat over ports in line therewith. The admission valves are not in positive connection with the valve gearing, but are tripped or disengaged at a point in the stroke determined by the governor or by hand, the closing being effected by a spring or equivalent device, thus giving a quick cut off, variable according to the load. The Corliss valve has the advantage of requiring little power to drive it, and has minimum clearance losses.

Cornice Bracket.—A bracket for carrying one or more insulators on the under side of the cornice of a building.

Cornish Boiler.—A cylindrical boiler with one longitudinal internal flue, the products of combustion passing around the shell of the boiler within the brickwork setting on their way to the chimney.

Cornish Pumping Engine.—A form of single acting condensing steam pump. A heavy rod or plunger, raised by the steam, forces up the water by its weight in descending.

Cornish Valve.—The equilibrium or double beat valve as applied to pumping engines, so called from its origin, together with many other inventions applied to draining mines, in the English county of *Cornwall.*

Corn Plaster Fuse.—A cylindrical form of safety fuse provided in telephone switchboards.

Coronæ.—The plural form of the Latin *corona* (a crown), applied to the crown shaped displays of light seen in the aurora borealis.

Corposant.—A name given by sailors to the static electric discharges sometimes seen on the tips of ships' masts, generally known among sailors as *St. Elmo's fire.*

Corpuscles.—Minute particles of matter, smaller than the chemical atom, conceived to exist even in the highest vacuum, and upon the presence and activity of which is based the theory of all electrical phenomena.

Correcting Factor of Wattmeter.—A necessary consideration in reading the indications of a wattmeter to allow for the self-induction in its coils.

Correcting Relay.—In quadruplex telegraphy, a relay interposed between the receiving relay and the sounder to guard against false signals.

Correlation of Energy.—The ability which any form of energy has to change into another form; as, when the potential energy in a voltaic cell becomes electricity.

Correspond.—To be like something else in the dimensions and arrangements of its parts; to be adapted; to suit; to agree.

Corrode.—To eat away by degrees; to wear away or diminish by gradually separating or destroying small particles of; as, by the action of a strong acid or a caustic alkali.

Corrosion.—Chemical action which causes destruction of the surface of a metal, usually by oxidation or *rusting*, often by the disintegrating influence of stray electric

currents or ground return currents in electric systems, known as *electrolytic corrosion;* the metal may be also eaten away by the action of acids present in water or in the surrounding air. To diminish corrosion of exposed surfaces, paints, oils, or other protective coatings are employed.

Corrugated Iron.—Sheet iron pressed or rolled into semicircular corrugations and galvanized; much used for roofing purposes and for covering the sides of more or less temporary structures.

Corundum.—A hard mineral consisting of crystalline alumina. Emery is a dark colored granular variety of the same. Corundum is used in powder of varying fineness, made up into wheels with resins, glue, etc., and is used in the form of different instruments; as, files, slabs, wheels, etc. Glued to some cheap cloth it is used by metal workers, and known as *emery cloth.*

Cosine.—In trigonometry, the sine of the complement of an angle. It may be represented as the length of the adjacent side or base of a triangle, of which the sine is the perpendicular or opposite side, or as the ratio existing between the adjacent side or base and the hypotenuse. Abbreviated as *cos.* or *cosin.*

Cosine Law.—The intensity of illumination received obliquely is proportional to the cosine of the angle which the luminous rays make with the normal to the illuminated surface.

Cosinusoid.—A curve made up of cosines.

Cotangent.—In trigonometry, the tangent of the complement of an arc or angle.

Cotter.—A wedge or taper key used to fasten parts of machinery together.

Cotter Pin.—A split key; properly a headless taper split pin, driven into its hole and expanded at the small end so that it cannot jar loose.

Cotton Waste.—Refuse thread from the operations of spinning and weaving cotton, largely used in cleaning machinery, and also for packing axle boxes of railway cars.

Coulisse—1. In carpentry, a grooved piece used for covering wires.

2. In civil engineering, a pair of battens, or a groove in which a sluice gate moves up and down.

Coulomb.—The practical unit of electrical *quantity;* it is the quantity of electricity delivered by a current of one ampere maintained for one second of time. A coulomb of electricity would pass in one second in a circuit whose resistance is one ohm when the pressure is one volt; the quantity of electricity which a condenser of one farad capacity will absorb when subjected to a pressure of one volt. The coulomb received its name in honor of the French experimenter.

Coulomb, Charles Augustin.—Born 1736, died 1806. A French physicist noted for his investigations in magnetism and electricity. In 1777 he obtained a prize for an essay on the construction of magnetic needles, and later gained two other prizes for essays on mechanical problems. He is best known as the inventor of the torsion balance. His name has been given to the unit of electric quantity in recognition of his services to electrical science. During the later years of his life he contributed to the work attending the introduction of the metric system by the French Government.

Coulomb Meter.—An instrument for measuring electrical quantity by indicating the number of coulombs which pass through a circuit in a given time.

Coloumb's Balance.—An instrument for determining by the torsion of a wire the action of the forces of attraction and repulsion exhibited between two electrified spheres.

Coulomb's Law.—The law of electrostatics first stated by Coulomb; that the force exerted between two charges of electricity is directly proportional to their product, and inversely proportional to the square of the distance between them.

Coulomb Volt.—A term sometimes applied to the *joule*, the practical C. G. S. unit of electric energy.

Counter.—1. A mechanism for registering or counting the revolutions or double strokes of an engine or pump. In an engine counter, water meter, or similar counter, whatever number of counter dials (or wheels) there may be, the right-hand always records 10; the next to the left 100; the 3rd, 1,000; the 4th, 10,000; the 5th, 100,000; and the 6th, 1,000,000. Hence, one having six dials can register 1,000,000 revolutions. When a counter has completed its full number of recording, all the numbers will show zero, to which must be added an imaginary *one*, making for seven dials or wheels, ten millions; and the next stroke of the engine will begin a new series with 1, etc.

2. The overhang of a ship's stern.

Counterbalance.—In engineering, a weight placed opposite a crank arm to balance the revolving weights and a certain proportion of those having a reciprocating action. On stationary and marine engines, it is fixed on the opposite side of the crank, but the usual custom with locomotives is to dispose of it upon the wheels near the rim.

Counter Clockwise Motion.—A circular motion, the *reverse* of the movement of the hands of a clock as seen when one reads the time; left handed or positive rotation.

Counter Communication Telephone Switch.—A switch device for a silence telephone cabinet which makes it impossible for a person desiring to use the telephone, to call up the central office without first obtaining the consent and co-operation of the attendant in charge.

Counter Electromotive Force.—An opposing electromotive force which resists the current in a circuit. It is an element to be often reckoned with in electrical work. In motors the rotation of the armature tends to set up a counter E. M. F. which reduces the *impressed* E. M F.; *i. e.*, the driving force applied to the terminals. Wherever in an electric circuit, current flows through some portion of the circuit in which there is an electromotive force, the current will there either receive or give up energy according to whether the electromotive force acts *with* the current or *against* it. Thus, in a circuit in which there is a dynamo and a motor, suppose each to be rotating right handedly and therefore generating an electromotive force tending upwards from the lower brush to the higher. In each case the upper brush is the positive one. But in the dynamo, where energy is being supplied to the circuit, the electromotive force is in the same direction as the current: whilst in the motor where work is being done, and energy is leaving the circuit, the electromotive force is in a direction which opposes the current.

Counter Electromotive Force Cell.—1. A cell set in the circuit of a storage battery to oppose, and thus reduce the charging current by the action of electrolysis.

2. Extra storage battery cells intended to maintain normal pressure in the battery when it is to be charged at an excessive pressure.

Counter Electromotive Force Lightning Arrester.—A lightning arrester, which, upon receiving a discharge of lightning, generates by induction a counter electromotive force to counteract the effect. It acts on the principle of a choking coil.

Counter Electromotive Force of Arc.—A counter electromotive force occurring in a voltaic arc between two carbons, resulting in a loss of potential at the crater of the arc owing to the volatilization of the carbon.

Counter Electromotive Force of Convective Discharge.—A resistance, similar to a counter electromotive force, offered to the course of a discharge through a vacuum.

Counter Electromotive Force of Electrolysis.—A counter electromotive force, occurring in the plating bath in the process of electroplating.

Counter Electromotive Force of Mutual Induction.—A counter electromotive force due to the induction between circuits.

Counter Electromotive Force of Polarization.—A force occurring in a voltaic cell as the result of polarization which conflicts with the current generated by the cell.

Counter Electromotive Force of Self-induction.—An electromotive force produced in the primary of a transformer in an alternating current circuit.

Counter Electromotive Force of Storage Battery.—A counter electromotive force developed in a storage battery which resists the charging current.

Counter Inductive Effect.—The resistance offered to an electric current by the force due to the effect of induction.

Counter Pressure.—A pressure which exerts an equal and opposite force to another; reaction of one pressure against another; *back pressure.*

Countersink.—A conical rose bit or fluted reamer, for enlarging bolt holes to a conical recess for the reception of the tapered head of the bolt, which is thus let into the material so that the bolt head is flush with the exterior surface.

Couple.—1. The two electrodes of a voltaic cell.

2. A pair of equal and parallel forces acting in opposite directions, tending to produce a motion of rotation in the body acted on.

Coupled Cells.—A group of voltaic cells connected to make a battery.

Couple Magnetic.—The turning moment which tends to rotate a magnetic needle, placed in the earth's field, into the plane of the magnetic meridian; the total force acting on either pole of a needle free to move in any direction is equal to the strength of that pole multiplied by the total intensity of the earth's field at that place.

Coupling.—1 The act of connecting a group of electric cells so as to form an electric battery. Cells may be coupled in three ways: 1, *series;* 2, *parallel,* and 3, *series multiple.* A series connection consists in connecting *unlike* poles; a parallel connection is made by connecting *like* poles, and a series multiple connection consists in connecting *in parallel* two batteries whose cells are connected *in series.*

2. The uniting of a number of dynamos in large generating stations so that as the load fluctuates it can be shifted from one to another as the case requires; or when the load exceeds the capacity of the largest dynamo in the plant the output of one can be added to that of another.

3. An attachment whereby one piece of mechanism constrains another part to follow the movements of the first; it may be an absolutely rigid connection as a *flanged coupling* to unite sections of shafting together; flexible within limits, as a *universal joint* or *a diaphragm coupling.*

Coupling Bolt.—A bolt in a flanged coupling connection, generally used for line shafting.

Coupling Box.—A metallic box consisting of a cast iron shell in two close fitting halves, for the purpose of properly and conveniently connecting the ends of electric conductors running through sections of underground tubes.

Coupling Clamp.—A coupling device for making an electric connection between the ends of underground wires.

Coupling Joint.—A flexible section of conducting material for uniting the ends of the wires inside the connecting boxes of underground electric tubes.

C. P.—1. Abbreviation for candle power.
2. Abbreviation for *chemically pure.*

C. R.—Abbreviation for *conductor resistance.*

Cracking.—In chemistry, the process of destructive distillation, or heating out of contact with air, in which most organic bodies undergo a complex decomposition, a number of fresh bodies being formed by a rearrangement of the atoms under the influence of the heat.

$C.^2$ R. Activity.—The electric activity wasted in heating the conductor, caused by the opposition offered to the flow of the current by the mass of the conductor; the I^2R activity.

Cradle Dynamometer.—A method of measuring the mechanical energy of a dynamo by suspending it in a cradle and observing the torque produced about the axis of the cradle.

Cradle Suspension of Car Motor.—A method of adjusting the motor of a street railway car upon its truck by resting it upon a cradle supported by springs.

Crampoon.—1. A hooked piece of iron, something like double calipers, for raising stones, lumber, and other heavy materials; also called *crampon.*

2. An iron attached to the foot for walking on ice, or climbing telegraph poles, etc.

Crane.—A machine for hoisting and lowering heavy weights. It consists of a vertical post or frame, which is rotatable on its axis, and a jib or projecting arm over which the chain or rope passes on its way from the winch at the foot of the post to the load to be lifted. Cranes are arranged to be operated by hand, steam, hydraulic power or electricity; they may also be operated by means of endless ropes or shafting and worm gearing from another source of power.

Crank.—In mechanics, a lever formed at right angles to a shaft or keyed thereto, by means of which the shaft may be turned or the motion of the shaft be imparted to another mechanism. The crank is the common device for converting reciprocating motion into rotary; as, in the ordinary direct acting engine.

Crank Case.—In engineering, the casing surrounding the moving parts of a small engine, protecting them against dust and damage, and acting as part of the framing in supporting the cylinders.

Crank Chamber.—The enclosed space of a small high speed engine or of an internal combustion motor; usually made water tight, so that there may be carried oil or oil and water up to the shaft level, in which the cranks dip at every revolution, splashing the lubricant over the moving parts. When no fluid is contained in the chamber, it is generally termed a *crank case.*

Cranking.—In motor cars, the act of rotating the motor, by means of a handle, in order to start it; turning it over until the explosive charge is ignited by an electric spark.

Crank Pin.—The cylindrical stud or pin at the extremity of a crank, opposite to the shaft and parallel with it, which affords attachment for the link or connecting rod by which the crank shaft is turned.

Crank Shaft.—The main shaft of an engine in which are formed the cranks for converting the reciprocating motion of the pistons into the rotary motion of the shafting. There are great varieties of forms, depending upon the type of engine. Small sizes are frequently bent from cylindrical bars.

Crater of Arc.—The concave effect produced upon the top of the positive carbon of an arc lamp by the action of the current.

Creeping.—The depositing of salts from the solution upon the sides of a voltaic cell by the action of capillarity, and the gradual further *creeping up* of the deposit which takes place unless prevented by the application of a coat of paraffin to the walls of the cell, or a layer of oil upon the surface of the solution; *saline creeping.*

Creeping of Belt.—The slip of the belting upon the driven pulley so that the speed of the driving pulley is not fully transmitted.

Creeping of Current.—1. The polarization occurring in the solution of a primary cell.

2. The spreading of an electric discharge over the surface of a non-conductor.

Creosote.—An oily liquid with a characteristic smoky smell, obtained by distillation from that portion of wood tar (principally beechwood), which distills between 400° and 425°, or that portion of *coal tar* which distills between 450° and 510°. Wood creosote is colorless, that from coal tar is greenish. It is used for *pickling wood* to preserve it, and as a disinfectant.

Creosoting.—The process of impregnating timber, with creosote as a preservative. The kiln or creosoter is a circular tube perhaps 100 feet long, into which four wheeled trucks are run, these being loaded with the sleepers so as to correspond with the cross-section of the kiln. The door is sealed when full, external steam heat applied and an exhausting air pump set in motion to draw all air and moisture from the pores of the wood and the interior of the kiln. When a sufficiently high vacuum is attained, boiling creosote is forced into the kiln until a pressure of 15 to 25 lbs. per sq. inch is reached, the pressure being maintained until the timber can absorb no more. The superfluous creosote is then run off, the door opened, and the cars hauled out; the sleepers being stacked in the stock yards by overhead transporters.

Crith.—A weight of one liter of hydrogen at a temperature of 0° Centigrade and a barometric pressure of 760 millimeters; proposed as the unit of weight for gaseous substances.

Critical Angle.—In optics, the angle of incidence beyond which rays of light striking the surface of a medium are no longer *refracted* into that medium, but are totally *reflected* from it.

Critical Current.—That strength of an electric current required to bring about some special effect in electric operation.

Critical Current of Dynamo.—The current generated by a dynamo such that a slight effect upon its speed may have a great effect upon its electromotive force, and is represented upon the characteristic curve by a bend, or distinct deflection from the straight line.

Critical Current of Magnetization.—The current applied to magnetize an iron core such that a slight increase in its strength will greatly increase the magnetization.

Critical Distance of Lateral Discharge.—The distance at which an electric discharge will cross an air gap rather than follow a metallic conductor having given resistance.

Critical Pressure.—In physics, the pressure causing the liquefaction of a gas, at or about its *critical temperature.*

Critical Speed of Dynamo.—1. The speed of rotation necessary for a dynamo to begin to excite its field.

2. The speed at which both the series and shunt coils of a compound wound dynamo generate the same potential when the full load is carried, as would be generated on open circuit using the shunt coil alone.

Critical Temperature.—In physics, the temperature at which a given substance

begins to change its state; as, from a solid to a liquid or *vice versa*. The critical temperature of gases is one above which it is impossible to liquefy them. The volume at this point is termed the *critical volume*, and this, together with the temperature, and the necessary pressure to produce liquefaction, are sometimes termed *critical data*.

C^2 R Loss.—The loss of energy of an electric current in passing through a conductor.

Crocker, Francis Bacon.—Born 1861. An American electrical engineer, noted for his special researches in connection with high potential direct current dynamos, unipolar dynamos, electric motors and batteries, electrochemistry, and the automatic regulation of alternating current systems.

Crookes' Dark Space.—A space at the negative electrode of a highly rarefied tube through which an electric discharge is passing, which appears dark in contrast to the luminous effect of the discharge, and which increases with the exhaustion of the tube; sometimes called, *Crookes' layer*.

Crookes' Effect.—The radiant effect produced in a vacuum glass tube in which the exhaustion has been carried to a high degree, when electricity is discharged through it between suitable electrodes. It receives its name from Sir William Crookes who discovered the phenomenon.

Crookes' Electric Radiometer.—An instrument for exhibiting the force of active radiant matter in a vacuum by the application of electricity.

Crookes' Radiometer.—An instrument for exhibiting the transformation of radiant energy into mechanical work. It consists of four slender vanes bearing discs of pith resting on a needle and free to turn upon it; the whole enclosed in a glass vessel from which the air has been exhausted. The impact of radiant energy against these discs causes them to revolve as if driven by the movement of air.

Crookes, Sir William.—Born 1832. An English chemist and electrician, noted for his researches in connection with radiant matter and high vacua. He discovered a new metal, *thallium* (1861), a sodium amalgamation process for separating gold and silver from their ores (1865), and a new method for spectroscopic investigations. He invented the radiometer, and later an improvement upon it which he called the otheoscope. His name has been given to the vacuum tube by means of which he discovered cathode rays (1873).

Crookes' Tubes.—Glass vacuum tubes in which exhaustion has been carried to a very high degree, containing platinum wires terminating in metallic plates. By passing into such tubes a current from an induction coil, luminous phenomena are seen which illustrate the character of radiant gaseous matter.

Cross.—1. An interference due to contact or similar cause between neighboring telegraph or telephone circuits.

2. Any accidental contact between electric wires or conductors.

Cross Ampere Turns.—Ampere turns on the armature of a dynamo opposed to the magnetization of the magnetic field.

Cross Arm.—A bar, usually of wood, attached horizontally to a pole to serve as a support for the insulators carrying overhead electric wires; *a telegraphic arm*.

Cross Arm Bolts.—Special bolts designed for securing cross arms to the poles.

Cross Arm Brace.—A brace of galvanized iron employed in pairs to reinforce and stiffen the cross arms on telegraph and telephone poles.

Cross Bending Strain.—The strain acting in a transverse direction on horizontal engine beds, pump beds and base plates, due to the thrusts of the rods. To reduce this to a minimum, the centers of the cylinders and rods are kept as low down as possible, lessening the leverage thereby.

Cross Bonding.—A connection made between the ground feeder, or conductor, and the rails of an electric railway in order to preserve a return circuit.

Cross Compound.—In engineering, a term applied to a design of compound stationary engine, in which the high and low pressure cylinders form distinct and separate engines, each upon its own bed, with the flywheel between them, the cranks being usually overhung. This type of engine is very accessible in all its parts, and the main bearings are easily kept in line.

Cross Connected Dynamo.—A dynamo having the coils of its armature connected to corresponding bars of the commutator.

Cross Connecting Board.—A board in telephone or telegraph exchanges into

which the terminals of the line are assembled so that they may be readily connected to any section of the switchboard, as desired; a *distributing board.*

Cross Connecting Conductors.—Conductors for the purpose of connecting the line terminals to the different sections of the switchboard.

Cross Current.—When two separately driven alternators are coupled in parallel and one lags behind the other in phase, a current that flows for a brief time from the leading to the lagging dynamo.

Crossed Arm Governor.—In engineering, a centrifugal governor whose arms are *crossed;* that is, each point of suspension is on the opposite side of the spindle to the weight. This causes the balls to vibrate in a parabolic path, ensuring more sensitive governing.

Crossed Belt.—One employed to drive a pulley in the opposite direction to its driver. The part of the belt going from the top of one pulley to the bottom of the other is turned half round so that the same belt face shall be in contact with each pulley, and that the two parts shall be edgewise where they pass each other. With a crossed belt *speed cones* may be of straight taper.

Cross Fire.—The escape of electric current from one telephone or telegraphic line to another as a result of faulty insulation. An intermittent or swinging cross fire is often due to wires which are too slack, being blown occasionally by the wind into contact.

Crosshead.—In engineering, the connection between the piston and connecting rods of a reciprocating engine. With marine engines of moderate size, and many small motors, it is sometimes an enlargement of the piston rod. In stationary and locomotive work, it is usually a separate steel casting, having a taper socket into which the piston rod is cottered, with a separate pin through the jaws of a double eye to serve as a gudgeon on which the connecting rod vibrates. In large marine engines, it is a steel block into which the piston rod is bolted, a projecting arm on either side affording attachment for the forked end of the connecting rod.

Crossing Cleat.—A cleat for interior wiring suitably grooved so as to allow electric wires to cross one another without making contact.

Crossing Frog.—A frog suspended on a trolley wire at the point where one line branches from another, for directing the trolley wheel to the proper line; a *trolley frog.*

Crossing Wires.—A temporary expedient when a defective section is found to exist in a telegraph circuit, for preserving the continuity of the circuit by crossing the wire over to a neighboring line till the fault is remedied.

Cross Magnetization.—Lines of magnetic force set up in the windings of a dynamo armature which oppose at right angles the lines of force created between the magnetic poles, thus tending to distort the field.

Crossover Block.—A block of insulating material designed to allow an electric wire safely to cross another in interior wiring without risk of making contact.

Cross System.—A method of running overhead wires to counteract the tendency to mutual induction between neighboring circuits, by crossing the wires at intervals so that they pass each other in frequently changing relations.

Cross Talk.—Conversation over one telephone circuit overheard in the telephone of another circuit, when their wires run side by side. This fault is due almost entirely to electrostatic induction.

Cross Wire Suspension.—A method of suspending an arc lamp from a cross wire by block and pulley.

Crow Foot.—A zinc electrode, suggesting a crow's foot in shape; used in a gravity cell.

Crown.—1. The higher part of any structure or thing with curved outline; as, the central part of a roadway, the summit of a hill, etc.

2. In building, the highest part of an arch or arched structure.

Crowning.—1. In civil engineering, the curvature given to the surface of a roadway, permitting water to run off on either side.

2. In mechanics, the convexity given to the middle of a pulley rim, thus keeping the belt in place and also permitting the latter to lie in a more natural position, while improving the *adhesion.*

Crown of Cups.—A primitive voltaic battery devised by Volta, consisting of a series of vessels filled with lime or dilute sulphuric acid, each one of which contained a plate of zinc and a plate of copper connected in series, the isolated zinc and copper plates in the first and last cell, respectively, forming the terminals of the battery.

Crown Telephone Receiver.—A form of receiver having a cluster of permanent magnets with the similar poles grouped at the pole piece within the coil, and the opposite coil connected to the edge of the diaphragm.

Crown Wheel.—In mechanics, a wheel with teeth or cogs, set at right angles to its circumference instead of radially, as in spur gearing. Called also a *face wheel.*

Crucible.—1. A pot made of clay, plumbago, or other refractory material, in which metals or alloys are melted.

2. The lowest part of a blast furnace, below the *hearth,* within which the molten metal collects. Its floor is known as the *sole.*

Crucible, Electric.—An electric furnace for melting substances which fuse only at very high temperatures; the heat is produced by an electric arc within the furnace.

Crucible Steel.—A homogeneous steel, obtained by melting pieces of suitable blister steel in covered crucibles of plumbago and fire clay; the crucibles are arranged in sixes or twelves in a reverberatory furnace. Several crucibles are poured simultaneously by well drilled workmen, to secure uniformity. This steel is more homogeneous than *shear steel* and possesses greater tenacity, with a fine granular structure. By the addition of manganese carbonate the property of weldability is restored to crucible steel and brittleness is corrected.

Crusher.—A term sometimes applied to a motor used to reduce the pressure on a feeder line by absorbing the extra voltage, when that line requires less pressure than that delivered by the main dynamo.

Crushing Strain.—One occasioned in a material by simple compression; as, by pressure on a column in the direction of its length.

Crushing Strength.—The ability of any material to resist strains due to compressive stresses. Generally speaking, a body which exhibits great resistance to crushing is deficient in tensile strength; as, cast iron or concrete.

Cryptoscope.—A name sometimes given to the fluoroscope, which is an opaque box or tube having at one end a screen coated with fluorescent material for the purpose of exhibiting the shadows cast by X-rays.

Cryptoscopic Screen.—A screen coated with fluorescent matter employed in the fluoroscope in X-ray work; a fluorescent screen.

Cryptoscopy.—The examination of the human body by the use of X-rays in connection with the fluoroscope· *fluoroscopy.*

Crystal.—1. A body having definite internal structure with the external form of a solid enclosed by a number of symmetrically arranged plane faces, varying in simplicity from a cube to a complex geometrical form.

2. Clear, pellucid and transparent, like ice.

3. Silica or quartz, in a transparent form; so called because the ancient Greeks believed the gem to be a manifestation of ice.

Crystal Detector.—In wireless telegraphy, an oscillation detector based upon the property possessed by a crystalline mass of carborundum, of acting as an oscillation detector when supplied with electrodes, converting the oscillations into direct current. The crystal is inserted in the circuit of the antenna, and shunted by another circuit containing a telephone and a battery. When oscillations are set up in the antenna, sounds are heard in the telephone.

Crystalline Deposit.—In electroplating, a deposit in the form of metallic crystals due to an excess of electric current through the plating bath.

Crystallization.—1. The formation of substances as symmetrical solids or crystals, which are definite geometrical figures bounded by flat surfaces. To the chemist and mineralogist the form and appearance of the crystal are generally sure indications of its constitution.

2. The arrangement of the molecules of a fluid substance or liquid into crystalline bodies on cooling, or through thickening by evaporation, as with saline solutions.

3. The rearrangement of the molecules of a metal into crystalline structure under alterations of stress or overload, as with a crane chain or a steel rail.

4. The depositing of crystals in a metal by the action of electrolysis.

Crystallization, Electric.—The transformation of a substance by electrical

means into a crystalline form. For instance, silver nitrate in solution may be decomposed by a current and yield crystals of metallic silver.

Crystallization of Iron.—This is affected by the conditions under which it is cooled. If cooled rapidly against a cold metallic surface it becomes chilled, and the crystals are long and needle-like. If cooled slowly the crystals are large and the grain is coarse. Crystals which are near the surface always arrange themselves at right angles to the surface. Crystals near the surface are always smaller than those nearer the central portions. The crystals of graphite mingled among those of the iron are also affected by the conditions of cooling, remaining uncombined in metal cooled slowly, but entering into chemical combination when cooled rapidly.

Crystalloids.—A class of bodies which, in a state of solution, diffuse easily through organic membranes, and are crystalline in structure. Crystalloids are opposed to *colloids*, from which they may be separated by a process called *dialysis*.

Cube.—A rectangular solid, measuring the same lineally in the three directions of length, breadth and thickness. Its contents are equal to the product of the lineal measurement of each dimension, hence the *third power* of a number is termed its *cube*, as it represents the product of three factors, each equal to the stated number. This is written a^3 or *a cubed*, as it equals $a\ a\ a$ or $a \times a \times a$.

Cube Knot.—A unit of volume applied in measuring the resistance of the insulation in submarine cables.

Cubic Foot.—The volume contained within a space one foot long, one foot broad and one foot deep; 12^3 or 1728 cubic inches, and $1/3^3$ or $1/27$ of a cubic yard. The usual *unit of capacity* in dealing with fluids or liquids, except for purposes of buying and selling, when either weights or gallons are employed.

Cubic Yard.—The customary unit for measuring excavations, embankments, and also concreting and masonry. It is an equivalent volume to that of a six sided figure or cube, each edge of which measures one yard or three feet.

Culm.—A name applied to various classes of coal, originally a Devonshire name for an impure form of coal found locally. Elsewhere it means, (*a*) slack coal; (*b*) breeze, as used in brick burning; (*c*) waste coal, mixed with slate or rubbish; (*d*) the dust or refuse of Pennsylvania anthracite, or the same when found in an impure or pulverulent state.

Cumulative.—Composed of parts in a heap; forming a mass; aggregated; augmenting; gaining, or giving force, by successive additions.

Cup.—A term largely applied to many mechanical details which present a resemblance to a drinking cup, either in form or in use; especially:

In lubrication, a vessel or small funnel for receiving oil, etc., and conveying it to a machinery part; an oil cup.

Cup Brush.—A brush for polishing the inner surfaces of cup shaped objects in preparation for electroplating.

Cupel.—In metallurgy, a small shallow dish about an inch in diameter, upon which assaying specimens are exposed, within the *muffle*, to the heat of the furnace. The cupel must be porous and very absorbent, and is usually made from ashes of the burnt bones of sheep and horses, washed repeatedly, pressed into form by means of a mould and pestle, dried and ignited to expel all moisture.

Cuprite.—The red oxide of copper; red copper; an important ore of copper occurring massive and in isometric crystals.

Cuprum.—In chemistry, the technical name for *copper*. Abbreviated Cu.

Cup Valve.—1. In steam engineering, a cup shaped or conical valve which is guided by a stem to and from its flaring seat.

2. A form of balance valve which opens simultaneously on top and sides.

3. A valve formed by an inverted cup over the end of a pipe or opening.

Curbed Signals.—Telegraphic signals transmitted by the process of curb signaling.

Curbing.—Applying the process of curb signaling to the transmitting of cable messages.

Curb Key.—In telegraphy, a special key designed for curb signaling over a submarine cable.

Curb Sender.—In submarine telegraphy, an automatic signaling apparatus for

insuring sharply distinct messages, by sending *curbed* signals. The message is punched on a strip of paper and passed through the transmitter by clockwork.

Curb Signaling.—A method of signaling through a submarine cable so as to prevent confusion due to induction, in which the original powerful signal is followed by one or more weak reversed currents which have the effect of hastening the main signal through the cable.

Curie, Mme. Marie Sklodowska.—Born 1867. A French scientist, widow of the late Pierre Curie, and joint discoverer, with him, of radium (1898).

Curie, Pierre.—Born 1859, died 1906. A French scientist. In 1896 he, together with his wife, began the study of Becquerel rays, which resulted in the discovery of two new metallic elements, *polonium* and *radium* (1898). In 1903 they jointly received the Davy medal of the Royal Society of London, and shared in the Nobel prize. In 1904 Curie was made professor of physics at the Sorbonne and the next year a member of the Institute of France.

Current Accumulator.—An apparatus for strengthening an electric current by moving a conductor through the influence of that current, so that the induced currents in the conductor act upon the circuit to increase its strength.

Current Commuter.—A name sometimes given to the commutator of a dynamo armature, which commutes the currents generated in the armature into a uniform direction.

Current Density.—1. The current intensity at any point in a conductor, as related to the area of the cross section at that point. According to Thompson the current density in the armature wire of a dynamo should not exceed 2500 amperes per square inch of area of cross section of conductor.

2. In electroplating, the current strength in relation to the amount of metal deposited.

Current Direction Indicator.—A device for indicating whether or not the direction of the current in a circuit is properly preserved.

Current Distribution.—The transmission of electricity to different points through a system of distributing conductors.

Current Diverter.—An occasional name for the rheostat used in trolley car motors.

Current Efficiency of Storage Battery.—The relation between the amount of available electric energy put out by a storage battery, and the amount of electricity absorbed by the battery in obtaining its charge.

Current, Electric.—1. The flow of electrical energy along a conductor from the higher to the lower of two points having different potentials. The "flow" is simply the effort to equalize the two potentials just as water runs from a higher to a lower level, or pressure; and the current may be maintained by preserving a constant difference of potential between the two connected points.

2. The amount of such electrical energy flowing per second along a conductor under a constant difference of potential.

Current Equalizer.—A mechanism for regulating the strength of the current in charging a storage battery, and similarly, of the current strength derived from a storage battery.

Current Governor.—Any regulating device for preserving the strength of an electric current uniform throughout the circuit.

Current Induction.—An induced E. M. F. produced by an electric current in one circuit and imposed upon another circuit, because some of the lines of force in one circuit cut the lines of the other; mutual induction.

Current Induction Telegraphy.—A method of telegraphy from a moving train, based on the principle of induction between an outside circuit and a circuit running parallel to it on the train.

Current Meter.—An instrument for measuring the strength of an electric current. For example, an *ammeter* is a current meter showing by direct reading the number of amperes of current flowing through a circuit.

Current Recording Meter.—An ammeter which records as well as indicates current strength.

Current Reverser.—Any switching instrument for reversing a current.

Current Rush.—An impetuous rushing of electricity which takes place upon con-

necting a transformer into an alternating circuit.

Current Sheet.—An electric current spread over a conducting surface and conceived of as flowing in the form of a sheet.

Currents of Motion.—Electric currents said to pass through muscular or nerve tissues in the human body when they are suddenly contracted or relaxed.

Currents of Rest.—Electric currents said to exist in human muscular and nerve tissue when in a state of rest.

Current Spiral.—A spiral coil of conducting wire through which an electric current flows.

Current Streamlets.—Slender threads of electricity supposed to flow in parallel lines through the mass of a conducting body.

Current Strength.—1. The amount of electricity that passes any cross section of a circuit in a second of time.

2. In a continuous current, the relation of the electromotive force to the resistance of the circuit.

3. In an alternating current, the relation of the electromotive force to the impedance of the circuit.

Current Transformation.—The changing of the character of a current, as when a direct current is changed to an alternating current, or a low tension current to one of high tension.

Current Turns.—The relation of the current flowing through a coil of wire to the number of turns in that coil.

Current Wave.—1. A succession of wave like motions set up in the medium surrounding an active electrical conductor.

2. An electric current flowing along a conductor in successive waves as a result of varying the electromotive force supplied to the circuit.

Curve Guy Poles.—Guy poles set at the curves in a trolley line, to which the trolley wire is braced by wire guys in order to preserve the proper relations of the wire in making the curve.

Curve of Cross System.—In the cross over system of overhead wiring, in order to nullify the influence of induction, the curve made in the wire at the cross arm where the change is made in the relations of neighboring wires.

Curve of Expansion.—In engineering, the curve traced by the pencil of an indicator during the expansion of steam or other working fluid, after cut off It is generally compared with two other curves, *isothermal* and *adiabatic*, for purposes of comparison.

Curve of Sines.—The curve representing graphically the vibration of a body oscillating like a pendulum according to the law of simple harmonic motion, having its abscissas proportional to the angle in its circle of reference, and its ordinates to the sine of the angle: it forms a so-called sinusoidal, or simple harmonic curve. In an alternating current, the value of the electromotive force may be represented at any moment by the curve of sines.

Curve of Torque.—One of the characteristic curves of a motor or dynamo showing the relations between the torque and current.

Curves, Magnetic.—If iron filings be sprinkled on a sheet of paper held in the field of a magnet, the filings on gently shaking the paper will arrange themselves in magnetic curves indicating the directions of the lines of force of the magnetic field.

Cushioning.—The compression of steam behind the piston of a steam engine, occasioned by closing the exhaust before the completion of the stroke. The cushioning serves to absorb the inertia of the moving parts and brings the piston to rest, preparatory for the next stroke.

Cushioning Chamber.—A device in a variety of mirror galvanometer for bringing the vibrations of the mirror quickly to rest.

Cut Gears.—A term applied to toothed wheels whose cogs have been formed by a machine, as distinguished from those whose teeth have been moulded or cast. The former, being mechanically accurate, require less clearance, and therefore run with less noise.

Cut In.—To insert a conducting appliance or medium into an electric circuit; to *switch on*.

Cut Off.—In engineering, the point at which the motion of the valve closes the port opening of a cylinder to steam, causing the remainder of the stroke to be effected by the expansive power of the fluid. It is generally expressed as a fraction or percentage of the stroke, but sometimes as so many inches. Properly speaking, this is called the *apparent cut off* and does not represent the *real cut off;* the latter is obtained by adding the *clearance* to the apparent cut off and expressing the sum as a percentage of the stroke.

Cut Off Valve.—In steam engines, a separate slide valve fitted to control the admission of steam, when it is necessary.

Cut Out.—1. To take out a conducting device or medium from an electric circuit; to switch off.

2. An electrical device to interrupt the flow of current through any particular apparatus or instrument, either automatically or by hand, more generally by short circuiting than by actually breaking the current.

Cut Out Block.—A block of porcelain or similar non-conducting material containing a safety fuse.

Cut Out Board.—A board for the purpose of carrying safety fuses.

Cut Out Box.—A box designed to hold a cut out fuse.

Cut Out Cabinet.—An enclosure in a building designed for the accommodation of cut outs.

Cut Out Switch.—A mechanism for switching any electric device out of its circuit.

Cutting and Holding Grapnel.—A grapnel for submarine cable work so constructed that it automatically cuts the cable after gripping it.

Cutting Lines of Force.—Causing a conductor to pass through a magnetic field in such a way as to cut the lines of force and thereby generate a current.

Cutting Nippers.—A sort of pincers, whose jaws are sharpened for cutting wire, etc. They are different from *pliers*, as they have no roughened jaws or lips for grasping the work, their function being cutting only, either at the side or the front of the jaws.

Cutting Pliers.—Grasping instruments for wire workers' use, having usually a square nose with roughened edges for seizing and twisting wire, with a cutting blade at the root of each jaw between which the wire may be cut.

Cyanide.—A salt of hydrocyanic acid, otherwise regarded as a compound of cyanogen with a metallic base; the most important are the cyanides of potassium, silver and mercury. In a crystalline form, cyanide of potassium is known to electroplaters as *cyanide powder*.

Cyanide Bath.—In electroplating, a bath in which potassium cyanide forms an important ingredient.

Cyanide of Potassium.—A white crystalline solid, highly poisonous and a powerful reducing agent, formed either by strongly heating potassium ferrocyanide or by neutralizing hydrocyanic acid with caustic potash. This cyanide is much used in photography, electroplating and laboratory processes; a weak solution readily dissolves finely divided gold, and is therefore employed to treat slimes and poor ores, especially those which have already been through the amalgamation process. The gold is subsequently precipitated from the solution by zinc, and the resultant cake is refined by cupellation.

Cycle.—1. A series of operations forming a closed circle, a fresh series beginning where another ends; as exemplified in the course of the steam with a marine engine, it being generated in the boilers, passing through pipes to the engines, doing work successively in the various cylinders, by virtue of the elastic force stored in it while being formed; escaping at a low exhaust pressure to the condenser, where it is converted into water, and as such, returned to the boiler once more.

2. The cycle of operations within the cylinders of an internal combustion motor; termed *two cycle* or *four cycle* on account of the number of strokes of the piston required to complete the series in each case.

Cycle of Alternations.—A full, or double alternation of an alternating electric current.

Cycle of Magnetization.—A complete wave of magnetization in a succession of periods of magnetic change.

Cyclic Magnetic Variations.—Periodically recurring variations in the earth's magnetic declination, taking place at long intervals of time.

Cyclic Magnetization.—The magnetization caused by applying cycles of magnetization to a susceptible substance.

Cyclic Motion.—Periodically recurring motion.

Cyclic Phase.—In physics, an expression denoting the orderly and cyclic succession of the various motions in a heat engine; as, *pre-admission, admission, expansion, release, exhaust, compression,* in a steam engine; and *suction, compression, explosion, exhaust,* in an internal combustion engine.

Cyclic Stability.—The constant condition of an electric current arrived at by the uniform periodicity of alternations in an alternating current.

Cyclometer.—An instrument for registering the number of revolutions made, or the distance measured, by a wheel or other rotating body.

Cylinder.—1. A circular body generated by the rotation of a straight line around an axis and parallel to same; a bored or hollow surface of a cylindrical outline.

2. In engineering, the essential part of a reciprocating engine; consisting of a cylindrically bored chamber with sealed ends, in which work is done by a fluid upon a *piston*, in moving it alternately from one end to the other.

Cylinder Capacity.—The volume of a cylinder, or the area of the piston multiplied by its stroke, and therefore, a direct factor in the measurement of the power of an engine.

Cylinder Cover.—In engineering, a circular disc of cast iron, which may be flat, ribbed or dished, forming the steam tight lid of a cylinder, usually at the end opposite to that through which the piston rod passes. Usually called, *cylinder head.*

Cylinder Jacket.—In steam engineering, an annular space surrounding the cylinder walls and through which live steam is circulated to lessen or prevent condensation of the steam within the cylinder.

Cylinder Oil.—A heavy mineral oil, of considerable viscosity and a high flash point, used to lubricate the cylinders and valves of a steam engine. On account of the high temperature organic oils may not be used, and a *flash point* of 500° or over is necessary, especially when working with *superheated steam.*

Cylindrical Armature.—A dynamo or motor armature having the general form of a cylinder; a drum armature.

Cylindrical Carbon Electrodes.—Carbons of cylindrical form for use as electrodes in arc lamps or battery cells.

Cylindrical Core.—A piece of iron shaped like a cylinder to serve as a solenoid core.

Cylindrical Electromagnet.—An electromagnet having a core shaped like a hollow cylinder.

Cylindrical Gauge.—In instruments, a gauge composed of two pieces, a plug gauge or solid cylinder furnished with a handle, and a collar gauge or hollow cylinder into which the plug gauge fits. These gauges are used as templets for boring and turning parts of machines which are required to correspond in dimensions.

Cylindrical Magnet.—A magnet in the form of a cylinder, or short rod with circular cross section; a *rod magnet.*

Cylindrical Vibrator.—A cylindrical weight suspended in such a manner as to exhibit the effect of torsion.

Cymometer.—An instrument devised by J. A. Fleming for the measurement of wave lengths and frequency in connection with wireless telegraphy. It is also useful in the measurement of small inductances and capacities. It consists primarily of an air cored wire coil in series with a condenser consisting of inner and outer metal tubes which form the two plates.

Cystoscopy, Electric.—In medical practice, the examination of the human bladder by means of a specially designed incandescent lamp.

D.—Abbreviation for diameter, in electrical calculations.

Daily Variation.—Slight variations shown by the magnetic needle at certain hours each day; *diurnal variation.*

Dalton's Law.—The pressure exerted on the interior walls of a vessel containing a mixture of gases is equal to the sum of the pressures which would be exerted if each of the gases occupied the vessel alone.

Damped Galvanometer.—A galvanometer provided with a device for damping the oscillations of the indicator, so that it comes quickly to rest after being deflected.

Damped Magnetic Needle.—A magnetic needle so adjusted as to come quickly to rest after being deflected.

Damped Vibrations.—Vibrations checked by opposing to them such a resistance as will quickly cause them to cease.

Damper.—1. A metallic tube which may be pressed over the core of an induction coil to reduce the induction and lessen the currents of the secondary circuit.

2. A resisting device for checking the oscillations of a magnetic needle.

3. Any arrangement, as a dash pot, for preventing sudden action.

4. A valve or door regulating the flow of heated gases through a chimney, or the entrance of air into the ash pit, thus controlling the rate of combustion.

Damper Regulator.—A device for controlling the rate of combustion in stationary boilers; a piston or weighted lever is connected by suitable mechanism with the dampers in the throat of the chimney, so that the gases may be throttled as steam exceeds or falls short of the required pressure.

Damping.—1. Offering a retarding force to control swinging vibrations or other motions and bring them quickly to rest.

2. A term denoting the decrease in the intensity of electric oscillations produced in a resonant circuit by electric resistance.

Damping Coil.—A coil designed to carry occasional electric currents, mounted near a galvanometer for the purpose of bringing the needle quickly to rest after deflection.

Damping Magnet.—A magnet used to act upon a needle or other moving body to damp its motion.

Damping Suspension.—A suspension so acted on by a damping device as to be free from swing.

Damping Tube.—A metal tube pressed over the core of an induction coil to reduce the induction and lessen the currents of the secondary circuit; a *damper.*

Damping Vessel.—A device usually consisting of a cylinder and piston, offering a retarding force for checking any sudden action; a *dash pot.*

Damp Steam.—In steam engineering, a term used in the same sense as *wet steam.*

Daniell, John Frederick.—Born 1790, died 1845. An English physicist and chemist, inventor of a constant type of voltaic cell (1836) known by his name.

Daniell's Cell.—A two fluid voltaic cell containing a zinc plate immersed in dilute sulphuric acid, and a copper plate in a saturated solution of copper sulphate; the two solutions being separated by a porous cup. This cell has a constant voltage and shows only slight polarization.

Dark Discharge.—A name given by Faraday to the non-luminous electric discharge occurring between the negative and positive electrodes in a vacuum tube.

Dark Light Frequencies.—Radio-activity so feeble as to fail to produce perceptible light.

d'Arsonval, Arsène.—Born 1851. A French physicist, noted for his researches in physical science; inventor of the aperiodic galvanometer and other important apparatus.

d'Arsonval Galvanometer.—A very sensitive, aperiodic or dead beat galvanometer in which the indicating coil is suspended in the field of a powerful horse shoe magnet; the invention of A. d'Arsonval.

d'Arsonval Method of Resuscitation.—1. Remove the body at once from the circuit by breaking contact with the conductors, using a dry stick of wood to roll the body over to one side, or to brush aside a wire, if that be conveying the current. When a stick is not at hand, any dry piece of clothing may be utilized to protect the hand in seizing the body of the victim.

2 Turn the body upon the back, loosen the collar and clothing about the neck, roll up a coat and place it under the shoulders, so as to throw the head back, and then make efforts to establish artificial respiration (in other words, make him breathe), just as would be done in case of drowning. To accomplish this, kneel at the subject's head, facing him, and seizing both arms draw them forcibly to their full length over his head, holding them there for two or three seconds only. Then carry the arms down to the sides and front of the chest, firmly compressing the chest walls, and expel the air from the lungs. Repeat this manoeuvre at least sixteen times per minute and continue at least an hour, or until natural respiration is established.

3. At the same time that this is being done, some one should grasp the tongue of the subject with a handkerchief or piece of cloth to prevent it slipping, and draw it forcibly out when the arms are extended above the head, and allow it to recede when the chest is compressed. This manoeuvre should likewise be repeated at least sixteen times per minute. If the teeth are clenched and the mouth cannot be opened readily to secure the tongue, force it open with a stick, a piece of wood, or the handle of a pocket knife. While this is being done, a physician should be summoned.

Dash Coil.—1. A multi-unit induction coil, for jump spark ignition of internal combustion engines, with a coil for each cylinder, the whole being enclosed in one case, with dash connections to the timing device upon the engine or cam shaft.

2. In synchronous ignition a single coil used with a multi-cylinder engine in connection with a *distributer*.

Dash Pot.—1. A device usually consisting of a cylinder and piston, offering a retarding force by which to check any sudden action.

2. A cylinder employed in steam engines which are fitted with trip gears; the dash pot is provided with a coil spring, a piston acted upon by steam or an air tight piston, behind which is a vacuum; the object in either case being to close the admission valves suddenly, as soon as they are released by the trip.

Data.—Things given; the plural of the Latin *datum*. Particularly:

1. Necessary details relative to a mathematical problem which are given when the problem is set.

2. Information, dimensions and particulars collected, either by experience, study or research, respecting technical subjects.

Davy Lamp.—A miner's safety lamp in which the air passages are covered with a cylinder of finely woven copper gauze, to cool the products of combustion to such an extent that surrounding gases will not be ignited by them.

Davy, Sir Humphry.—Born 1778, died 1829. An English chemist, famous for his researches in electro-chemistry. He was an extremely precocious boy, with a remarkable memory and an aptitude for scientific study. His early education in natural science he obtained from a saddler of Penzance, and in 1795, at the age of seventeen, he began his career as a chemist. His untiring energy in the laboratory led to many discoveries which attracted the attention of the scientific world. He discovered the elementary existence of potassium, sodium, and chlorine, and the properties of numerous gases and chemicals by electrolytic experiments, while his public lectures drew large and brilliant audiences. He recognized the talents of Faraday, and appointed him assistant in his laboratory. In 1815, he invented the miners' safety lamp, in recognition of which he was created baronet in 1818.

Day Load.—A load carried by an electrical machine during the day as distinguished from its load at night.

D. B. Switch.—Abbreviation for double break switch.

D. C.—Abbreviation for direct current.

Dead Beat.—A term applied to instruments having indicators which are prevented from tedious swinging back and forth after deflection, by being heavily damped so that they come to rest at once.

Dead Beat Discharge.—An electric discharge which does not oscillate.

Dead Beat Galvanometer.—A thoroughly damped galvanometer which gives its readings without useless swinging of the needle before coming to rest; an *aperiodic* galvanometer.

Dead Bright.—In machinery, a term applied to the surfaces of machinery which are finished with dead smooth files and oil until all tool marks are erased, the grains closed up and a polished face appears.

Dead Center.—1. The point at which the connecting rod of a steam engine has no power to turn a crank. It occurs when the position of the crank shaft, crank pin and connecting rod, are all in a straight line; that is, at each end of a stroke.

Dead Dipping.—Dipping metallic objects after electroplating into such acids as will give a dull luster to the surface of the metal, as opposed to *bright* dipping.

Dead Earth.—In telegraphy, a fault in the line involving a complete grounding or connection with the earth; a *total earth.*

Dead Ended Wire.—A line wire terminated by having its end fastened to an insulator.

Dead Ending.—Anchoring the end of a wire to an insulator.

Dead End of a Pipe.—The closed end of a pipe or system of pipes.

Deadening.—In building, filling or lining material used to render walls and floors less pervious to sound.

Dead Grate.—Those portions of the grate bar surface, along the fire box sides and ends, without openings for air supply; generally formed as a trough, on the edges of which are hooked the other bars, the hollow being filled with fire clay.

Dead Ground.—The same as dead earth.

Dead Hole.—In machinery, a hole bored in metal for a certain distance, but not entirely through.

Dead Load.—One that is put on by imperceptible degrees and that remains steady, such as the weight of a boiler or an engine on its foundation; opposed to *live load.*

Dead Man.—A pole support consisting of a heavy wooden bar terminating in a broad U-shaped iron fork, designed to prop a telegraph pole while being raised; a *butt prop.*

Dead Plate.—That part of the bottom of a furnace which consists simply of an iron plate on which the fuel is first thrown.

Dead Point.—The extremity of stroke of a piston in either direction, when it is unable to exert any rotative effort upon a crank.

Dead Point of Armature.—Such a relation of a motor armature to the field that it cannot start under the action of the driving current.

Dead Resistance.—A resistance free from self-induction.

Dead Turns.—That portion of the wire on an armature which comes outside of the magnetic field and is not effective in producing electromotive force. The number of dead turns is about 20% of the total number of turns.

Dead Water.—In steam engineering, the water which lies below the heating surface in a steam boiler, and where circulation is extremely sluggish.

Dead Weight.—Weight or load directly applied to an object, as in a dead weight safety valve.

Dead Wires.—1. Useless or abandoned wires.

2. Wires on a dynamo armature that fail to contribute to the electromotive force during the rotation of the armature in a magnetic field.

3. Wires on a motor armature which do not contribute to the torque when an electric current is sent through them.

Deafening.—In architecture, the lining paper used to prevent the passage of sound through floors, partitions, etc.

Death, Electric.—Death caused by the passage of an electric current of considerable strength through the body. When the current is sufficiently strong death is said to be painless, hence the adoption of so-called *electrocution* as a means of capital punishment.

Decade Resistance Box.—A simple form of resistance box provided with two sets of ten coils; one set of one ohm resistance each, and the other of ten ohms resistance each. By inserting two plugs, one in the tens and the other in the units resistances, any combination may easily be made; also called a decimal rheostat.

Decalescence.—The sudden absorption of heat occurring at a certain stage during the

process of heating a bar of iron or steel; the *reverse* of recalescence.

Decay of Waves.—The reduction of alternating wave amplitudes when subjected to any interference.

Deci.—A prefix often used with a physical unit to designate a quantity one-tenth of that unit.

Deci-ampere.—A unit of electric current equal to the tenth part of an ampere.

Deci-ampere Balance.—An ammeter balance designed to measure the strength of electric currents in deci-ampere amounts.

Deci-lux.—The tenth part of a *lux*, or standard of illumination.

Decimal Candle.—The *bougie-decimale*, a French standard of illumination equal to one-twentieth of a *violle*, or slightly less than the British standard candle.

Decimal Equivalent.—A fractional or duodecimal measurement expressed as a decimal; as, .0625 is the decimal equivalent of 1-16.

Decimeter.—A measure of length in the metric system; one-tenth of a meter, equal to 3.937 inches.

Deck Cable Lead.—Pulleys or guides, set upon the deck of a cable ship at intervals from the cable tank to the stern of the vessel, to assist the operation of laying the cable.

Deck Planer.—A rotary electrical tool for planing off the deck of a ship.

Declination.—The angle between the magnetic and geographic meridian. Since the earth's magnetic poles do not coincide with the geographic poles, the magnetic needle does not point exactly north and south, but varies more or less in different parts of the earth's surface; this variation is called the *declination*.

Declinometer.—An instrument consisting of a telephone combined with a magnetic compass, designed to measure the declination of the magnetic needle, and note its variations.

Decohere.—To cease to cling together or cohere; to fall apart.

Decoherer.—In wireless telegraphy, a device, usually electromagnetic, for causing a coherer to lose the coherence acquired under the action of the electric wave, preparatory to the reception of new signals.

Decomposition.—The process of resolving a substance into its constituent elements or atoms; analysis.

Decomposition, Electric.—The decomposing of a substance by the action of an electric current; *electrolysis*.

Decomposition, Electrolytic.—The process of decomposing a liquid solution called *electrolyte*, into its chemical elements by the action of an electric current.

Decorative Series Lamps.—Incandescent electric lamps connected in series and arranged to make a decorative display.

Decrement.—The ratio of one oscillation to the succeeding one, of a suspension needle which has been disturbed, the swings gradually decreasing in amplitude on account of *damping*.

Dedendum.—In toothed wheels, the root of the tooth, or that part within the pitch circle. The dedendum circle is the circle within the pitch circle, to which the bottom of each tooth extends.

De-energize.—To cut off from an electric apparatus the electric current upon which it depends for its operation.

Deep Seated Eddy Currents.—Useless electric currents circulating deep in the mass of a solid conductor.

Deflagration.—Rapid and violent combustion or volatilization.

Deflagration, Electric.—Volatilization of a metal by the action of a powerful electric current.

Deflagrator.—An early form of voltaic battery of low internal resistance designed for purposes of electric deflagration.

Deflecting Field.—In a galvanometer, the current which is tested produces a magnetic field which deflects the needle to an amount depending upon the intensity of the field, the deflection being a measure of the current strength.

Deflection.—1. The alteration in form of any material under stress; deformation caused by the imposition of a load either tensile, compressive, torsional or transverse.

2. The distance or angle by which one line departs from another.

Deflection Compass.—An instrument used in meteorology to observe the declination of the magnetized needle, and note its variations; frequently made self registering by periodical photographs. Useful to tell the hourly variations of the magnet and foretell electrical storms; a declinometer.

Deflection Method.—A method of electrical measurement in which the amount of deflection of the index needle is taken as the measure of the electric force acting upon or through an instrument, as distinguished from the *null* or *zero* method.

Deflection of Magnetic Needle.—1. The *declination.*

2. The deflection of a magnetic indicator from its plane of normal rest along the earth's meridian into another position, under the influence of an artificial magnetic field.

Deflector.—A term of general application for a plate or other suitably shaped fitting employed to turn the course of a stream of liquid or gases in a desired direction; deflectors are commonly fitted to furnaces and fire boxes to direct the course of the hot gases, and to protect the door from the flame.

Deformation.—The distortion of the mass of a solid body due to the relative displacement of its parts after a heavy strain.

Degeneration of Energy.—The deterioration or weakening of energy or force.

Degrees.—The circumference of every circle is supposed to be divided into 360 equal parts, called degrees; thus, a degree is $\frac{1}{360}$th of the circumference of any circle. A degree is divided into 60 parts called minutes, expressed by (′), and each minute is divided into 60 seconds, expressed by (″), so that the circumference of any circle contains 21,600 minutes or 1,296,000 seconds.

Deka.—A prefix often used with a physical unit to designate a quantity ten times as great.

Deka-ampere.—A unit of electric current equal to ten amperes.

Deka-ampere Balance.—An ammeter balance designed to measure the strength of electric currents in amounts of tens of amperes.

De la Rive's Floating Battery.—This consists of a small floating cell having immersed therein a galvanic couple connected through a coil of wire placed above. An exciting solution is poured in the cell, and the latter as it floats in a larger vessel rotates until the coil and magnetic needle are at right angles to each other.

A magnet acts in accordance with Ampère's theory, to attract or repel the coil.

De Laval, Carl Gustaf Patrick.—Born 1845. A Swedish inventor. After a technical university course at Stockholm and several years of study at Upsala, specializing in physics and mathematics, he commenced his career in the service of a mining company, and later became mechanical engineer in the Kloster Iron Works in Germany. There he began producing a series of valuable inventions, the first of which was a strainer for separating air in Bessemer converters, and another a crucible for galvanizing purposes. His experiments on centrifugal machinery that followed. led to the perfection of his centrifugal cream separator which has proved of immense value to the dairy industry of the world. He also perfected the "lactometer" for determining the percentage of butter-fat in milk. It was his work with the separator that led to his conception of the steam turbine, embodying the principle of the engine devised by Hero 1900 years before. He brought out his inventions in 1882, producing the first practical machine a year later, and in 1888 invented the diverging expansion nozzle, and soon after the flexible shaft, which combined to assure the efficiency of the De Laval steam turbine. He received many high honors at the hands of learned societies and from the Swedish Government.

Deliquescence.—The dissolving of a salt or other crystal substance in the moisture absorbed by it from the atmosphere.

Delivered Power.—In electrical distribution, the electricity delivered at the remote end of the line without regard to that put into the line at the source.

Delivery Wires.—The service wires, by means of which electric power is delivered to a consumer from the mains.

Delta (Δ).—1. The fourth letter of the Greek alphabet.

2. The name adopted for a bronze alloy containing cast iron.

Delta (Δ) **Connection.**—The connection of the circuits in a three phase system in which the terminal connections are triangular, like the Greek letter *delta;* triangle or ring connection.

Delta Current.—The current flowing from one line to the other in the delta connection of a three phase system.

Delta Metal.—In metallurgy, an alloy of copper and zinc, with a small quantity of iron. It is prepared in various grades, both cast and forged.

Delta Potential.—The difference of potential between adjacent lines in a delta connected three phase system.

Delta Three Phase System.—The ring connection applied to a three phase system, so that the transmission wires are joined to the three corners of a triangle, resembling the Greek letter *delta.*

Demagnetization.—The process of removing the magnetism from a magnetic substance. A magnet may be demagnetized 1, by bringing its poles into contact with like poles; 2, by heating to redness; 3, by passing it through a series of cycles in a magnetic field which is at first strong, then gradually diminishing in intensity to zero; 4, by reversing the directions of the motions by which its magnetism was originally imparted.

Demagnetizing Current.—A current employed to oppose a magnetic field so as to deprive it of its magnetism.

Demagnetizing Force.—Magnetic lines of force arising in a bar of iron or steel in an opposite direction to the force magnetizing it, and tending to neutralize that force; and, in the case of a permanent magnet, tending to demagnetize the bar.

Demand Indicator.—A form of electric meter designed to measure the maximum demand of a consumer, or the highest amount of electrical energy consumed by him at one time; a rebate indicator.

Demarcation Current.—In electro-therapeutics, a current obtained from an injured muscular tissue.

D. E. M. F.—Abbreviation for *direct electromotive force.*

Densimeter.—An instrument used to determine the amount of moisture present in the atmosphere; usually called *hydrometer.*

Density, Electric.—The quantity of electricity on a unit of area at any part of a charged body.

Density of Charge.—The amount of electricity at any point of a charged surface; *i. e.*, the number of units of electricity per unit of area; electric *density.*

Density of Current.—The current strength per unit of surface of cross section of an electric conductor.

Density of Electrification.—The amount of electricity at any point on a surface electrified by an electrostatic charge.

Density of Field.—The quantity of electromagnetic lines of force existing in a unit cross section area of an electromagnetic field.

Dental Mallet, Electric.—An instrument used by dentists for hammering tooth fillings. It is operated by an electromagnet, the mechanism being so arranged that it strikes a rapid series of blows.

Dephased.—Made to vary in phase.

Depolarization.—The process of preserving the activity of a voltaic cell by preventing polarization.

Depolarize.—To prevent polarization in a voltaic cell.

Depolarizer.—An oxidizing substance used for fixing the hydrogen derived from the decomposition of the acid by the zinc in primary cells.

Depolarizing Fluid.—A powerful chemical agent employed to depolarize a voltaic cell.

Depositing Cell.—In electro-metallurgy, a cell in which to make electro-metallurgical deposits.

Deposition.—1. The electrolytic precipitation of a metal; electroplating.

2. An action whereby matter in solution is precipitated upon a surface, as the process of *electro deposition,* in which a coating of precious metal is bestowed upon base or inferior material.

Derivation.—A name sometimes given to a derived circuit.

Derived Circuit.—A branch of a divided circuit carrying a derived current; a *shunt circuit.*

Derived Circuit Arc Lamp.—A constant current series arc lamp having one magnet winding in series with the arc and one in shunt with it. The current being constant, the series winding by itself would cause a pull tending to hold the carbons apart, but the shunt winding is so connected as to produce an opposing effect, and since this effect increases with the length of the arc. the core of the magnet is drawn down until the carbons approach each other; a differential arc lamp.

Derived Current.—A current which passes through a shunt or derived circuit.

Derived Units.—In the C. G. S. system of measurement, certain secondary units based upon the three *fundamental* units which are the *centimeter,* or unit of length; the *gram,* or unit of mass; the *second,* or unit of time.

Derrick.—An apparatus of the crane type, used to lift heavy weights.

Derrick Brace.—A diagonal member of the framing of a derrick, such as is used in well boring. The horizontal members are known as *girths* or *girts.*

Derrick Pole.—A tripod leg of a portable derrick; as, a *gin pole.*

Design.—The preliminary calculation of dimensions and the drawing from those dimensions of the parts of a machine or structure. Much design is based upon actual physical and mathematical research, and, to be worthy the name, should be based upon a new and original arrangement of mechanical details.

Desk Loop.—A circuit used in a telegraph station for connecting the instruments upon a desk in that office to the instruments of the main line.

Desk Push.—A push button fitted to a desk for ringing an electric bell, or other similar purpose; a *table push.*

Desk Set.—A convenient type of telephone instrument designed to stand upon a desk, so that the subscriber need not leave his desk in order to use the telephone.

Destructive Distillation.—The decomposition of a substance by great heat in a retort, and the collection of the volatile products evolved by the chemical process undergone; as when coal is heated so as to yield gas, naphtha, tar, etc., leaving a residue of coke.

Detail Drawings.—These are ordinarily of full size, and often are called working drawings, as they give all necessary particulars.

Detector.—1. In wireless telegraphy, a general term applied to receiving instruments, such as the coherer, responder, etc., for revealing or detecting electromagnetic waves.

2. A small electric device consisting of a galvanometer or current indicator and several primary cells, employed for testing the continuity of electric circuits.

Detector Galvanometer.—Any simple galvanometer sufficiently delicate for ordinary use in detecting the presence of electricity; the lineman's detector.

Detector Peg.—A peg employed in a detector galvanometer.

Deterioration of Incandescent Lamp.—The decrease in candle power of an incandescent lamp due to prolonged use, whereby the filament "ages" with a corresponding waste of electric energy.

Detonator.—An explosive capsule containing fulminate of mercury or similar substance, which by electricity or a fuse is caused to detonate high explosives.

Detorsion Bar.—A metal bar employed in a declinometer to remove the torsion of the thread which suspends the magnet.

Developed Diagram.—In armature construction, a method of showing the windings and connections in which the cylindrical surface is shown "developed," or rolled out flat upon the paper, while the ends of the armature are represented as they actually appear.

Developed Winding.—The winding of a dynamo, spread or mapped out in a diagram.

Development.—1. The progress of advancing change by which anything grows toward maturity or perfection.

2. In mathematics, the process by which a mathematical expression is changed into another of equivalent value in an expanded form.

Deviation.—1. Divergence from a course, or rule.

2. The deflection of the mariner's compass owing to the attraction of the metallic masses of which the ship is composed.

Device.—That which is devised or formed by design; a contrivance; an invention.

Devil Claws.—A claw like instrument used in overhead line construction.

Dew.—Moisture, condensed from the atmosphere and gathered in small drops upon the upper surface of plants and other bodies.

Dew Point.—The temperature of the atmosphere at which dew would form or condensation would occur.

Dextrorsal Solenoid.—A solenoid with right handed winding; a dextrorsal helix.

Diacritical Current.—A current which, flowing through a solenoid, is sufficient to bring the iron core to one-half its point of magnetic saturation.

Diacritical Number.—The number of ampere turns in a solenoid required to create a magnetic condition in the iron core equal to one-half magnetic saturation.

Diacritical Point.—The coefficient of magnetic saturation producing in an iron core a condition equal to one-half its maximum magnetization.

Diagometer.—An instrument consisting of a dry pile and magnetic needle for measuring the electro-conductive power of a substance, and thereby detecting adulterations and impurities in the substance.

Diagonal.—1. Crossing at an angle with one of the sides.

2. A line joining two opposite angles of a quadrilateral figure, and dividing it into two parts.

Diagram.—1. A skeleton geometrical drawing, illustrating the principles or application of a mechanism.

2. A figure traced by the pencil of an indicator.

Dial.—1. A graduated circular plate upon which anything is indicated by a needle; as, in a steam gauge or numbered face plate.

2. A magnetic compass used in underground surveying.

Dial Bridge.—A form of resistance bridge having its coils arranged in dials, the contacts being made by a movable arm instead of by the insertion of plugs.

Dial Instrument.—Any instrument for electrical measurement in which indications are made by the deflection of a needle or pointer over the face of a dial; a pointer instrument.

Dial Telegraphy.—A method of telegraphy in which a magnetic needle, swinging over a dial marked with the letters of the alphabet, is used for receiving the messages; step by step, or needle telegraphy.

Dialysis.—The process of separating a substance into *colloids* and *crystalloids* by taking advantage of the difference of their diffusibility through a membrane.

Dialysing.—Subjecting a substance to dialysis.

Diamagnetic.—A term applied to substances which are feebly repelled from the poles of a magnet, as distinguished from *paramagnetic* substances which are attracted to the magnet. Bismuth is the most strongly diamagnetic body known.

Diamagnetic Permeability.—The susceptibility to magnetization possessed by diamagnetic bodies.

Diamagnetic Polarity.—The magnetic property of diamagnetic substances in virtue of which they appear to be repelled from the poles of a magnet.

Diamagnetism.—The property of being apparently repelled from a magnet.

Diamagnetometer.—An instrument for measuring, or determining diamagnetism.

Diamagnets.—A name given to diamagnetic substances after undergoing magnetic induction, to distinguish them from magnets.

Diameter of a Circle.—A straight line passing through its center and terminating at both ends, in the circumference.

Diameter of Commutation.—The line passing through the center and circumference of the commutator, marking the points upon which the brushes must rest to insure sparkless commutation.

Diametral Pitch.—A modern method of computing the pitch of *machine cut* toothed wheels, in terms of a certain number of teeth per inch of diameter of pitch circle. To proportion the speeds of wheels is only a question of the ratio between the diameters, the pitch depending upon the strength of tooth required.

Diaphragm.—1. A thin disc of an elastic substance capable of being vibrated by sound or other wave motion; as, the diaphragm of a telephone receiver.

2. The porous partition employed in *electric osmose.*

3. A variety of porous vessel used in certain forms of voltaic cells.

4. A disc for regulating the light to be measured in a photometer.

Diaphragm Current.—An electric current due to the potential difference on the opposite sides of a porous diaphragm through which a liquid is being forced.

Diaphragm Photometer.—A photometer which measures the intensity of light by its effect upon the opposite faces of a diaphragm or screen.

Diathermal.—Capacity for transmitting radiant heat; freely permeable by radiant or reflected heat.

Dice Box Insulator.—A line insulator resembling a pair of inverted cones united at the vertices.

Dielectric.—1. Any non-conducting medium which intervenes between two conductors and permits electrostatic attraction and repulsion to take place across it; usually the dielectric is air, sometimes glass or ebonite.

2. A non-conductor, in general.

Dielectric Absorption.—The absorption of electricity that takes place in a dielectric.

Dielectric Capacity.—The inductivity or specific inductive capacity of a substance, being its ability to convey the influence of an electrified body. If the inductivity of dry air is taken as 1, the dielectric capacity of any other substance is measured by the ratio of the capacity of a condenser when its plates are separated by that substance to the capacity of the same condenser with its plates separated by air.

Dielectric Circuit.—A circuit made up in a greater or less degree of dielectric substances, as distinguished from a circuit through conductors.

Dielectric Coefficient or Constant.—The same as dielectric capacity or specific inductive capacity.

Dielectric Current.—The rate of change of electric displacement produced in a dielectric; the displacement current.

Dielectric Density of a Gas.—The amount of electric force a gas can sustain between opposite charges of electricity before it gives way and permits a disruptive discharge to take place through it; dielectric strength.

Dielectric Displacement.—Tubes of force acting through a dielectric medium which is subject to electrostatic forces.

Dielectric Hysteresis.—A property of condensers in alternating current circuits, by virtue of which heat is generated by the energy expended in reversing the sign of the charge between the two coatings of the condenser; electrostatic hysteresis.

Dielectric Medium.—Any non-conducting medium acting as a dielectric.

Dielectric Power.—The inductivity, or specific inductive capacity of a substance, being its ability to convey the influence of an electrified body.

Dielectric Resistance.—The resistance offered by a dielectric to the electric force acting upon it.

Dielectric Strain.—The deformed condition which occurs in a solid dielectric under the stress of an electric charge upon its surfaces; as when a Leyden jar dilates, or even breaks, under the force of the charge.

Dielectric Strength.—The maximum voltage that an insulating substance or device will resist without permitting a disruptive discharge through it.

Dielectric Strength of Gas.—The degree of electric force a gas can sustain between opposite charges of electricity before

it gives way and permits a disruptive discharge to take place through it.

Dielectric Stress.—The electric force producing a strain in the dielectric medium through which it acts.

Dielectrol.—A trade name for an insulating paraffin varnish, which has a sufficiently high melting point to adhere to a copper coil under working conditions.

Diesel Engine.—A type of internal combustion engine designed to operate on gaseous or liquid fuel, and to work under a principle which involves the production of very high temperatures during its cycle of operations by the compression of the air in the working cylinder prior to the introduction of the fuel. The air is compressed to about 500 lbs. which raises its temperature to about 1000° Fahr. At this moment, which is the beginning of the power stroke, the fuel is introduced into the heated air in the cylinder and is ignited by its high temperature. The fuel is regulated by the action of a governor which automatically controls the amount supplied according to the varying load.

Dietrine.—A trade name for a compound prepared for insulating purposes.

Difference of Electric Potential.—The difference of electrical condition between two points in an electrical field involving work to be done by a unit of electricity in passing from one point to another; the difference of electric *level* which causes a current to flow from the higher to the lower; *electric pressure* or *voltage.*

Difference of Magnetic Potential.—The work required to be done between two points in moving a unit N pole from one point to the other.

Difference of Potential.—The relation between two points in space considered with respect to the power to do work involved in the movement of matter from one point to another, as when water seeks a lower level; potential difference.

Difference of Thermal Pressure.—The difference of temperature between two portions of a heat conducting body such that the heat tends to flow in the direction of lower temperature.

Differential.—Relating to, constituting or marking a difference; having different velocities.

Differential Arc Lamp.—A form of arc lamp in series, in which the arc is maintained by the use of a series coil of low resistance for striking the arc, and a shunt coil of high resistance for feeding the carbons forward when the length of the arc becomes too great; a derived circuit arc lamp.

Differential Coils.—Resistance coils employed in a differential galvanometer, being so arranged that the circuit divides; one part of the current flowing through the unknown resistance and one coil, while the other part flows through the known resistance and the other coil in the opposite direction.

Differential Duplex.—Duplex telegraphy employing differentially wound coils in the transmitting and receiving instruments; a method most frequently used in overland telegraphy.

Differential Electric Bell.—An electric bell having coils wound differentially.

Differential Electromagnet.—An electromagnet with differential winding.

Differential Equation.—An equation expressing a relation between unknown functions and their differential coefficients.

Differential Galvanometer.—A galvanometer in which the needle is suspended between two coils of equal resistance wound so as to act with equal force on the needle; it is useful for showing when the currents in two branch circuits are equal.

Differential Lamp.—A type of constant current series arc lamp in which the mechanism is provided with two coils which act against each other. One is a series coil tending to lift the upper carbon holder and lengthen the arc, and the other a shunt coil tending to lift the lower carbon holder and shorten the arc.

Differentially Wound Dynamo.—A dynamo having compound wound field magnets.

Differentially Wound Motor.—A motor with a compound wound field in which the series and shunt coils oppose each other.

Differential Method.—1. In duplex telegraphy, a method in which the coils of the

transmitting and receiving instruments are differentially wound.

2. In quadruplex telegraphy, a method involving a double differential duplex system.

Differential Pulley.—An arrangement of the differential windlass, in which the velocity of a movable pulley embraced by an endless rope or chain is very small, as the latter is wound off the smaller diameter while being wound on the larger.

Differential Pump.—A pump having two pistons of different diameters, used as an intensifier or accumulator in hydraulic engineering, etc. The fluid under pressure is in contact with the larger piston and the increment of pressure on the smaller piston is proportional to the ratio between the two areas.

Differential Quadruplex Telegraphy.—Quadruplex telegraphy employing the differential system.

Differential Relay.—A telegraphic relay, containing two coils of equal resistance wound differentially.

Differential Screw.—A device for obtaining great pressure through the prolonged action of a small power. A screwed spindle, working within a nut in a press frame, is threaded internally for the reception of another screw of the same hand, but of slightly finer pitch, this last screw being attached to the die head of the press.

Differential Thermopile.—A thermoelectric pile having opposite forces exposed to different sources of heat so that the two heat intensities may be compared.

Differential Voltmeter.—An instrument consisting of two separate decomposition cells; one is placed in a circuit whose resistance is known and the other in a circuit whose resistance is to be determined.

Differential Winding.—A method of winding the coils of a magnet with double coils, producing opposite poles.

Differential Winding of Field.—A method of winding a field magnet with series and shunt coils so that each exerts an opposing force upon the other.

Diffraction.—The breaking up of a beam of light into its component colors, due to the interference of the rays when deflected at the edge of an opaque body or through a narrow slit.

Diffraction Photometer.—A photometer in which a concave lens is introduced to increase the diffraction of the light rays, and thus make it possible to use a shorter bar in testing powerful lights.

Diffusion.—A term relating to the flow of an electric current through a conducting substance of varying cross sectional area. There is difference in the density of the current in different parts of the conducting substance due to the varying area and other causes.

Diffusion Creep.—A term signifying the passage of a current through an electrolyte, if there be a sufficient potential difference when electrodes of an active circuit are immersed in the solution. The current spreads out in every direction.

Diffusion Globes.—Globes designed for diffusing the light of an electric lamp.

Diffusion of Electric Current.—The uneven distribution of electricity in passing through a conducting body of irregular cross section; diffusion creep.

Diffusion of Electric Waves.—The dispersion of electric waves through the ether in every direction.

Diffusion of Electro-therapeutic Current.—In electro-therapeutics, the distribution of the current in different parts of the body between the points at which the electrodes are applied.

Diffusion of Gases.—The diffusion through each other which takes place when two gases are placed in contact. Even if a porous membrane be placed between them this process is only slightly retarded.

Diffusion of Magnetic Flux.—The dissipation or spread of magnetic flux in directions outside of its direct path between the magnetic poles; also called *diffusion of lines of force.*

Diffusivity.—In heat transference, the quotient of the conductivity of a body by its specific heat.

Digging Spoon.—A shovel shaped like a spoon with a long handle, for digging holes

for telegraph poles; a spoon shovel, or Spanish spoon.

Dilation, Electric.—The dilation or increase in size occurring in a body when charged with electricity.

Dilatometer.—An instrument for determining the amount of expansion a liquid undergoes when heated.

Diminished Electric Irritability.—In electro-therapeutics, the lessening of irritability in nerve tissue by the action of electricity.

Dimmer.—A resistance inserted in a lighting circuit for shunting or by-passing a variable portion of the current, thus "dimming" the lights in the circuit; an arrangement specially serviceable for theatrical purposes; *a theatre dimmer.*

Diode Working.—In telegraphy, the simultaneous transmission of two messages over one line.

Diopter.—A unit for expressing the refractive power of a lens, being the power of a lens whose focal distance is equal to one meter.

Dioptric.—Relating to the science of dioptrics.

Dioptrics.—That branch of the science of optics which treats of the refraction of light; opposed to *catoptrics.*

Dioptric Shade.—A shade which by refracting the rays of a source of light cuts off the illumination in certain directions.

Dip Cell.—A cell in which one of the electrodes is withdrawn from the solution when not in use; also called *plunge cell.*

Dip Circle.—A vertical graduated circle in which a dipping needle swings in measuring the magnetic inclination.

Diphase.—A term sometimes used for two phase.

Diphaser.—A name sometimes given to a *two phase alternator.*

Diplex Telegraphy.—The simultaneous telegraphic transmission of two messages in one direction over the same wire.

Diplex Telephony.—The simultaneous transmission of two telephone messages in one direction over the same wire.

Diplex Transmission.—Transmission of two messages simultaneously in one direction over the same wire.

Dip of Line Wire.—The sagging of a wire in the spaces between poles or other supports.

Dip of Magnetic Needle.—If a magnetic needle be suspended by its middle so as to be free to turn in a vertical plane, one end of it will hang lower than the other at most parts of the earth's surface. In the northern hemisphere, the N end of the needle will dip, in the southern hemisphere the S end will dip. At the magnetic poles, which do not correspond with the geographic poles, the needle would point straight down. This action is also known as the *inclination of the needle.* There is no dip at the magnetic equator or circle passing around the earth midway in intensity between the earth's magnetic poles.

Dipolar.—Having two magnetic poles; bipolar.

Dipping.—1. In electro-metallurgy, a method of applying a thin coating of metal to an article by dipping it into the proper solution.

2. A method of cleaning articles for electroplating by dipping them into cleansing acids. A bath in which rough articles are steeped for a considerable time is known as a "pickle", while a *dip* acts on smooth surfaces.

Dipping Basket or Bowl.—An openwork basket of stoneware or similar material, for holding articles to be cleansed for electroplating by the dipping process.

Dipping Compass.—An instrument sometimes called an inclinometer, used to measure the angle of dip or inclination of the magnetic needle.

Dipping Hook.—A metal hook from which articles are hung that are to be cleansed for electroplating by dipping.

Dipping Needle.—A magnetic needle turning in a vertical circle, and exactly balanced on its center of gravity, for measuring the inclination or dip in an inclinometer or inclination compass.

Dipping Wire.—A wire for securing articles that are to be cleaned for electroplating by dipping.

Dips.—In electroplating, acid solutions prepared for dipping articles to be plated; also called *steeps*.

Direct Acting Engine.—In steam engineering, an engine in which the action of the piston is transmitted directly to the crank shaft.

Direct Control Switchboard.—One in which the switching and measuring apparatus are mounted directly upon the switchboard.

Direct Coupled Dynamo.—A dynamo having the shaft of its armature coupled directly to the shaft which drives it.

Direct Coupling.—Connecting the shaft of a dynamo armature directly to the shaft which drives it.

Direct Current.—An electric current constant in *direction*, though not necessarily so in *value*. A direct current, constant in both value and direction as the result of constant pressure, is called a *continuous current*.

Direct Current Converter.—A machine for converting a direct current of one voltage to a direct current of another voltage.

Direct Current Dynamo or Generator.—A dynamo generating direct currents, which may or may not be continuous currents.

Direct Current Motor.—A motor operated by direct currents, as distinguished from one driven by alternating currents.

Direct Drive.—A method of driving a dynamo by direct connection with the steam engine, thus doing away with belting and counter shafting, and eliminating the power losses and noise associated with belt driven machinery. Direct driven dynamos are designed to run at a lower speed than belt driven ones because the inherent speed of engines is less than that of generators.

Direct Driven Dynamo.—A dynamo driven by direct connection with a steam engine, without the intervention of belting and shafting.

Directed Streaming Discharge.—A disruptive electric discharge of high frequency forming a cone shaped luminous stream.

Direct Electromotive Force.—1. The active electromotive force moving in a circuit, as distinguished from a *counter* electromotive force opposing it.

2. A continuous, as distinguished from an alternating electromotive force.

Direct Excitation.—The excitation of a dynamo by direct currents furnished from a source outside of itself; the excitation of a separately excited dynamo.

Direct Induced Current.—The current induced in an electric circuit by the breaking of the circuit; a break induced current.

Directing Clock.—In a system of electric time distribution, the *master* or controlling clock.

Directing Magnet.—A compensating magnet to influence the action of a magnetic needle.

Direct Inker.—An ink recording Morse register for use in a telegraphic line circuit, and not in a local circuit.

Direction of Current.—The direction in which an electric current is said to flow. It is assumed to be *from* a positively electrified body *to* a negatively electrified body; an assumption based upon the theory that the positive electric state has a higher potential than the negative state.

Direction of Force.—In mechanics, the line along which a force acts, whether it is productive of actual motion or of pressure or tension only.

Direction of Magnetic Flux.—The direction which lines of magnetic force are assumed to take in passing out of the positive pole of a magnet and re-entering the negative pole.

Direction of Magnetic Lines of Force.—The assumed flow of lines of magnetic or electrostatic force from the north to the south pole.

Direction of Negative Rotation.—A rotation about an axis in the same direction as that of the hands of a clock as seen from the front of the clock; a clockwise rotation.

Direction of Positive Rotation.—A rotation about an axis in the opposite direction from that of the hands of a clock

as seen from the front of the clock; a counter clockwise rotation.

Directive Tendency.—The tendency of a magnetic needle to point in the direction of the earth's magnetic poles.

Direct Lightning Discharge.—The original discharge of lightning, as distinguished from the back stroke which frequently accompanies it.

Direct Reading Galvanometer.—A galvanometer having a scale graduated by volts or amperes instead of degrees, so that the absolute value of the current strength may be read off without computation.

Direct Reading Potentiometer.—An apparatus for measuring differences of potential, such that the pressure may be read directly from its scale.

Direct Sounder.—A sounder for use in a telegraph line circuit, and not in a local circuit.

Direct Working of Sounder.—The operation of a sounder without the aid of a relay to reinforce it.

Disc.—A cylinder whose length is very short in proportion to its diameter; a round plate with a hole in its center; in refrigeration, a thin circular piece of cast iron made in halves, so that they may be secured together on a pipe, in order to increase its radiating surface; also called a *gill.*

Disc Armature.—A dynamo armature in the form of a disc on which the coils are wound flat.

Disc Electrodes.—Carbon electrodes in the form of discs, at one time used in all night arc lamps.

Disc Electrometer.—An instrument for measuring the attraction between an electrified and a non-electrified disc. It is similar to a balance in form, having at one end a light scale pan and at the other a disc hung above a fixed insulated disc, to which the charge to be measured is imparted.

Disc Fan.—An air propeller, usually driven by an electric motor, shaped somewhat like a ship's screw, and mounted in a cylindrical casing, delivering air parallel to its axis.

Discharge.—1. The effort to overcome differences of potential which takes place between two charged terminals when a connection is made between them. Discharges may occur in a great variety of ways and assume many forms.

2. To bring about an electric discharge by connecting two charged points.

3. The removal of a charge from the surface of any charged conductor by connecting it with the earth, or another conductor.

4. The removal of a charge by means of a stream of electrified air particles.

Discharge Key.—A key for sending a discharge through a galvanometer.

Discharge of Magnetism.—Loss of magnetism occurring in the field magnets of a dynamo so that they fail to generate an electric current.

Discharger.—A device consisting of a jointed brass rod provided with brass knobs and a glass handle, for discharging a Leyden jar; *discharging tongs.*

Discharge Through Gases.—The passage of an electric current through gases with an effect similar to that of electrolysis, being accompanied by the breaking up of gaseous molecules and the interchange of atoms.

Discharge Valve.—1. Any delivery valve, as, from a pump, tank, etc.

2. A self-acting valve, placed on a ship's side, permitting the circulating water, bilge water, etc., to be *discharged* overboard (hence the name), while preventing the ingress of water from the sea. Discharge valves are usually mushroom non-return valves, with a weighted spindle to keep them on the seat, and are not supposed to be capable of screwing down, etc.

Discharging Rate.—The rate measured by the strength of the discharging current, at which a secondary or storage battery gives up electric energy.

Discharging Rod.—A jointed metal extension rod with insulated handles, and having metal balls at each end, employed to discharge a Leyden jar or condenser.

Discharging Tongs.—A discharging rod in two bent parts connected with an insulated handle, resembling a pair of tongs.

Discoidal Winding.—The method of flat winding used on a disc armature.

Disconnect.—1. To take an electro-receptive apparatus out of a circuit.

2. To break an electric circuit.

Disconnection.—1. The breaking of an electric circuit.

2. The cutting of an electro-receptive apparatus out of a circuit.

3. A fault arising in a circuit as the result of a break in the circuit.

4. Disconnections are classified as, (a) *total*, indicating an absolute separation; as, by the opening of a switch; (b) *partial*, as by dirty contact, loose binding screw or badly soldered joint; (c) *intermittent*, as by a broken insulated conductor, the ends being held together by the insulation and any motion or vibration tending to bring them into contact.

Disconnector.—A device for opening a circuit, or for cutting out an electro-receptive device.

Disc Winding.—An extended radial winding treated as a drum winding, in which the periphery corresponds to the back ends of the drum, and the magnet poles are usually arranged so as to face the side or sides of the disc.

Disc Wound Transformer.—A transformer built up of coils wound separately into discs and piled alternately on top of one another; a series connection of the sections being used for high voltages and parallel connection for low voltages.

Dis-electrification.—The depriving of a charged body of its electric charge.

Disintegration.—The mechanical act of separation into particles, as opposed to the chemical process of decomposition or resolution into elements.

Disintegration of Storage Cell.—The dislodging of the active material from the plate or grid of a secondary battery, due to excessive rate of discharge.

Disintegration Theory.—A theory, advanced to explain the phenomena of radio-activity, that the atoms of radio-active substances undergo spontaneous disintegration, in the course of which parts of the atom escape in the emission of radiations.

Dispersing Pad Electrode.—A pad electrode used in electro-therapeutics for applying strong currents to the human body and diffusing them over a wide area.

Dispersion Photometer.—A photometer in which the rays of light to be measured are made to pass through a convex lens, and thus *dispersed*. In this way, an intense light like that of an arc lamp, may be more readily measured in terms of a standard candle.

Displacement Current.—The rate of change of electric displacement produced in a dielectric; a *dielectric current*.

Displacement, Electric.—Tubes of force acting through a dielectric medium, subject to electrostatic forces.

Displacement Flux.—The flow of the lines of electric displacement.

Displacement Lines.—The lines along which the movement of the displacement current or flux takes place.

Disruptive Conduction.—The conduction of electricity associated with a disruptive discharge.

Disruptive Discharge.—An electrostatic discharge which suddenly bursts across a dielectric medium.

Disruptive Strength of Dielectric.—The mechanical stress a dielectric medium can bear before giving way to a disruptive discharge.

Dissimulated Electricity.—A term sometimes applied to a charge of electricity upon the surface of a conductor, when it is attracted by the presence of a neighboring charge of the opposite kind; a *bound charge*.

Dissipation of Charge.—The gradual leaking away of an electric charge from a conductor, which takes place in spite of the best of insulation.

Dissipation of Energy.—The degeneration of energy into forms in which it is no longer available for work.

Dissipativity.—The rate at which energy is dissipated.

Dissociate.—To break up a compound by great heat into the elements of which it is made up.

Dissociation.—In chemistry, the process of breaking up a compound into its constituent elements. It is often accomplished by great heat.

Dissociation Theory.—A theory advanced by Arrhenius in 1887, upon which is largely based the electro-chemical science of to-day. He held that the electrical conductance of a solution was due entirely to the dissociated parts of the molecules. He ascribed electrical charges to these dissociated parts, and called them *ions*.

Dissolve.—To convert from a solid to a fluid state; as, to dissolve resin in alcohol, or a salt in a liquid.

Dissonance, Electric.—The opposite of electric consonance; a condition existing in alternating currents having phases in opposition.

Dissymmetrical Alternations.—A wave motion in which the frequencies are unequal in value.

Dissymmetrical Field.—A magnetic field containing an irregular distribution of lines of force.

Distance Piece.—A thimble or sleeve placed over a bolt or rivet to maintain a set distance between the two thicknesses of material which are united by it.

Distant Battery.—In telegraphy, a battery stationed at the remote end of the line.

Distant Station.—In telegraphy, the remote station or end of the line, as distinguished from the home station.

Distillate.—Any liquid that is a product of distillation. The lighter hydrocarbons obtained from the first distillation of petroleum which have to be redistilled to prepare them for the market; or any similar product of initial distillation which has to undergo further treatment.

Distillation.—An operation by which two or more liquids having different boiling points may be separated. It consists of a still in which the mixed liquids are boiled, and a worm coil in which the resulting vapors are cooled and allowed to run into different receptacles. Beccaria discovered that when a liquid is electrified its rate of evaporation is increased; and it has been shown by Crookes that negative electrification is more efficient in increasing the rate of evaporation than that of the positive sign.

Distillation, Electric.—The evaporation of a liquid and the condensation of the vapors to liquid again, aided by the electrification of the liquid to be distilled.

Distorsion.—The deformation of a medium as the result of a stress, strain or other similar influence.

Distorsional Elasticity.—Elasticity occurring in a body as the result of distorsion.

Distorsionless Cable.—A cable forming a part of a distorsionless telegraphic circuit.

Distorsion of Field.—A distorted condition of the magnetic field of a dynamo, due to the rotation of the armature against the mutual attraction existing between itself and the field magnets.

Distributed Capacity.—The capacity of a circuit considered with regard to the entire length of the circuit.

Distributed Inductance.—The inductance of a circuit considered with relation to the entire length of the circuit.

Distributed Load.—In mechanics, when a load is spread over the surface or area of a beam, girder or floor, so as to weigh it down equally.

Distributed Winding.—Armature coils evenly and regularly distributed over the surface of the armature.

Distributer.—In synchronous ignition, a combination of two timing devices attached to one common shaft and operated by the engine. A primary timer makes and breaks the primary circuit at the time a spark is required; a similar device working in step switches the secondary current to the different cylinders in proper sequence.

Distributing Board.—1. In a central telephone exchange, a board or frame by means of which the line wires entering the exchange are distributed to their proper numbers on the switchboard, also permitting easy access for making changes in the connections, and allowing for the introduction of test clips to simplify testing for faults in the lines; a cross connecting board.

2. In a distribution system, an insulated board by which branch circuits are led from electric mains.

Distributing Box.—1. A box containing all the safety fuses at a distributing point of a system of electrical distribution.

2. An arrangement whereby arc and incandescent lamps may be connected at the same time on one circuit.

3. A device by which a set of series incandescent lamps may be cut into an arc lamp circuit.

Distributing Box for Arc Lamp Circuits.—An arrangement whereby arc and incandescent lamps may be operated at the same time on one continuous current circuit.

Distributing Box of Conduit.—In an electric conduit system, a box in which connections may be made between branch wires and the main cable. The distributing box is often reached through a manhole.

Distributing Brushes of Motor.—The brushes which bear upon a motor commutator, and convey to it the current which drives the armature.

Distributing Centre.—A central point of electric distribution.

Distributing Mains.—The principal conductors in a system of electric distribution.

Distributing Point.—A junction point in an electrical distributing system, at which the cut outs of all the sub-mains and secondary conductors are collected.

Distributing Station.—A central station for electric distribution.

Distributing Switch.—A switch for cutting a number of distributing circuits in or out of a main circuit or electric source.

Distributing Switchboard.—A switchboard to which a number of electrical circuits are connected; a *multiple* switchboard.

Distributing Valve.—A combination of triple valve, checks and high speed reducing valve, designed especially for use on locomotives with certain applications of the Westinghouse air brake.

Distribution.—In engineering, the operation by which steam is admitted into and taken out of a cylinder at each stroke of the piston.

Distribution of Charge.—The spreading of an electric charge, in even or uneven densities, over the surface of charged bodies.

Distribution of Electricity.—The process of transmitting electricity for use at points more or less remote from electric sources and central stations, through various circuits and branches into suitable electro-receptive devices.

Distribution of Electricity by Alternating Currents.—The transmission of electric energy through alternating currents after being acted on by transformers set in the circuits.

Distribution of Electricity by Alternating Currents Through Condensers.—A system of transmitting electric energy from an alternating current dynamo, employing condensers to reduce high potential currents to currents of low potential, for the use of lamps or other electric devices.

Distribution of Electricity by Constant Potential Circuits.—Electrical distribution to receptive devices joined in parallel between constant potential mains.

Distribution of Electricity by Direct Currents Through Transformers.—A method of driving a dynamo on a direct current circuit by the use of motor-dynamos for raising or lowering the pressure applied to the motor terminals.

Distribution of Electricity by Motor-dynamos.—A system of driving dynamos on a direct current circuit by the use of motor-dynamos for raising or lowering the pressure.

Distribution of Electric Power.—The process of transforming mechanical work into electric energy, and distributing it along circuits to motors which convert it into mechanical work again.

Distributor.—A conducting main in a system of parallel distribution.

District Call Box.—A box supplied with make and break attachments which are set in motion by the pulling of a lever, thus transmitting electric signals to a central office indicating the service wanted and the location of the call.

Diurnal Currents.—Earth currents which flow between the various points of a telegraphic circuit each day.

Diurnal Load Factor.—The ratio of the actual output of an electric plant for twenty-four hours to the output it would have made if working constantly at maximum load for that time.

Diurnal Variation.—Slight variations exhibited by the magnetic needle at certain hours each day; daily variation.

Divalent.—In chemistry, a term applied to an element, one atom of which can unite with two atoms of hydrogen; also called, *bivalent.* Divalent elements are known as *dyads.*

Divergent Magnetic Flux.—Magnetic flux that diffuses with lessening strength through a magnetized body.

Diverging Lens Photometer.—A photometer provided with a convex lens for dispersing the rays of an intense light so that a strong light, like that of an arc lamp, may be measured in terms of a standard candle.

Diverging Magnetic Flux.—Magnetic flux that diffuses itself with lessening strength as it proceeds over or through a magnetized body.

Diversity Factor.—The ratio of the average electrical supply to the maximum supply delivered to a consumer during a given time.

Diverter.—In electric traction, a name given to a certain type of motor starting-coil, probably because some of the applied voltage is diverted from the motor in forcing the current through the coil against its resistance.

Divided Circuit.—A circuit branched for electric distribution.

Divided Core.—A dynamo or motor armature core which is built up of a series of thin discs of soft sheet iron or steel for the purpose of reducing eddy current losses. To effect insulation between the discs, their surfaces are allowed to rust, or sometimes pieces of tissue paper are interposed between them; also called, *laminated core.*

Divided Magnetic Circuit.—A magnetic circuit branching in different directions.

Divided Touch Magnetization. — A method of magnetizing a steel bar, in which the bar is stroked with the opposite poles of two other bar magnets, beginning at the middle and drawing them apart to the ends; double touch magnetization.

Dividing Engine.—A machine for dividing scales or standards of linear measurement into exact parts, and ruling the divisions upon metal bars, plates, dials, etc.

Division Operator.—In railway telegraphy, an operator having charge of a section of the system.

Doctor.—In electroplating, a device for applying a coating to surfaces that are too large to be wholly immersed in the bath.

Dolly.—In electroplating, a polishing brush composed of rings of cloth gripped in a wooden holder and fitted to a lathe.

Dome.—In a steam boiler, a cylindrical reservoir mounted on the upper surface of the boiler to increase the steam room; steam dome.

Dome Cap.—A cover or door for the top of the steam dome of a boiler.

Domestic Telephone Switchboard.—A private switchboard for making telephone connections with various parts of the house.

Door Bell Pull, Electric.—A device for closing an electric circuit which acts by the pull of a bell handle.

Door Contact Lamp.—A lamp which is lighted by an electric contact made when a door is swung open or shut.

Door Opener, Electric.—An electric contrivance by which a door may be opened by opening or closing a contact from a distance.

Door Push.—An alarm contact by which a signal is given when a door is opened or closed.

Door Trigger.—A catch which makes or breaks a circuit to give an alarm when a door is opened or closed.

Dot and Dash Code.—A name sometimes given to the Morse telegraphic alphabet.

Dotting Contact.—An electrical contact obtained between two contact points.

Double Acting Pump.—A pump in which the piston forces the water on one side, while drawing it into its cylinder on the other side.

Double Alternation.—A cycle of alternation; a complete wave.

Double Armature Windings.—Two sets of coils wound upon an armature and connected to alternate bars of the commutator.

Double Block Duplex.—In telegraphy, a form of Wheatstone differential duplex sometimes used on cable circuits, in which signaling and reading condensers are included in the system.

Double Bracket Pole.—A pole for supporting double brackets in a system of overhead line construction.

Double Bracket Trolley Suspension.—A method of suspending the trolley wire in a double track railway from double brackets extending on either sides of a line of posts erected between the tracks; center post construction.

Double Break Knife Switch.—A knife switch in which each blade is provided with two terminals besides the hing-clip. When the switch is open the blades are "dead."

Double Bronze Wire.—A variety of wire conductor of great strength, composed of a core of aluminum bronze sheathed with a copper brass coating.

Double Carbon Lamp.—An all night arc lamp provided with two pairs of carbons, fitted to a mechanical device for changing over the current from one pair to the other when the first pair is nearly consumed; a *twin carbon lamp.*

Double Circuit Dynamo.—A dynamo connected with two distinct circuits.

Double Conductor Cable.—A cable containing two distinct conductors insulated from each other.

Double Cone Insulator.—An insulator through which the line wire passes. It is supported by two inverted truncated cones which, joined at their vertices, form a tube.

Double Connector.—A binding screw suitable for connecting the ends of two wires.

Double Contact Key.—A key for closing two, or either of two, separate circuits.

Double Contact Push.—A push operating two contacts, simultaneously opening one and closing the other.

Double Contact Push Button.—A push button capable of making two contacts.

Double Cord Multiple Switchboard.—A telephone multiple switchboard in which the plugs are provided with cords having two wires instead of single wires.

Double Cord Switchboard.—A telephone switchboard having connecting cords composed of two wires instead of single wires.

Double Cup Insulator.—A line wire insulator, usually of glass, resembling in shape two inverted cups set one over the other.

Double Curb.—A method of telegraphic signaling in which two or more weak reversed currents are sent directly after the original powerful signals for the purpose of hastening it through the line.

Double Curb Working.—Using the double curb method of telegraphic signaling.

Double Current Generator.—A dynamo that produces both direct and alternating currents.

Double Current Repeater.—A repeater or translator employed in the double current system of telegraphy.

Double Current Telegraphy.—A system of telegraphy employed upon long lines for increasing the speed of working, and for obtaining greater permanence of adjustment. A polarized relay is always used, and a current called the "spacing" current is sent in a reverse direction to the "marking" current (which completes the local circuit) for restoring the tongue of the relay to the spacing side.

Double Current Transmitter.—The transmitter employed in the double current system of telegraphy, in which the key at rest sends out a "spacing" current followed by a "marking" current when the key is depressed.

Double Current Working.—The use of double currents in telegraphy.

Double Curve Pull-over.—A trolley hanger designed to hold the trolley wire at a curve. It is provided with two extension lugs for the attachment of strain wires; a *double pull-over.*

Double Deck Switchboard.—A telephone switchboard having its jacks arranged in two horizontal parallel rows.

Double Expansion.—The same as *compound;* a type of engine in which the steam or other working fluid is expanded in two successive cylinders, doing work on the piston of each, thus dividing the *temperature range* into two stages, and thereby reducing the amount of condensation that would occur if the entire expansion took place in one cylinder.

Double Field Magnet.—A dynamo field magnet provided with two pairs of poles; the exciting coils are wound upon what may be regarded as the yokes of the magnets. The direction of the electric current flowing in the magnetizing coils is such that two similar poles are produced in each pole piece.

Double Filament Lamp.—An incandescent lamp having two filaments usually of different lengths and of different resistance. The short filament is of very low candle power and is not in circuit with the longer filament.

Double Flexible Conductor.—A flexible conductor containing two insulated wires.

Double Fluid Cell.—A voltaic cell containing two different fluids as electrolytes; a *two fluid cell.*

Double Fluid Theory.—A theory once advanced that electricity existed in nature as two "imponderable" fluids, one positive and the other negative.

Double Focus X-ray Tube.—A vacuum tube containing two anti-cathodes for producing X-rays by means of an alternating current.

Double Insulation.—An insulation by which a conductor is protected in two separate places, so that if the insulation at one point fails, the other can be depended upon.

Double Key Tapper.—In single needle telegraphy, a signaling key consisting of two horizontal levers normally resting against a metal strip joined to the zinc pole of the battery, while at the other end another strip connects with the plus pole; a *double tapper.*

Double Layer Winding.—A form of bipolar direct current armature winding having the conductors placed in the slots in two layers, one side of each coil being placed at the bottom of the slot, the other side at the top in order to make all connections identical.

Double Liquid Cell.—A primary cell having two different solutions as electrolytes.

Double Loop.—In telegraphy, two loops for joining a couple of branch offices with the main office.

Double Magnet Dynamo.—A dynamo provided with a field magnet wound with two coils arranged so as to produce consequent poles.

Double Needle Telegraphy.—A method of needle telegraphy, employing two needles on the dial of the receiving instrument joined to two separate wires, as distinguished from single needle telegraphy.

Double Parallel Winding.—A form of armature winding in which the coil terminals, instead of being connected to adjacent segments, are connected to alternate segments. When this winding is used, each commutator brush must be thick enough to always touch two segments, otherwise the proper division of current between the two windings would not be preserved.

Double Pen Telegraph Register.—A device for recording a telegraphic message upon a strip of paper, by the use of two pens instead of one.

Double Petticoat Insulator.—A line wire insulator having a deeply grooved rim making two flanges separated by an air space, so as to increase the path of leakage.

Double Plug.—A contact plug for switch boards provided with two contacts, at the tip and sleeve, respectively, for making connection with the two terminals of the conductor; a *double peg.*

Double Pole.—A pair of telegraph poles securely braced together and erected side by side; an *H pole.*

Double Pole Bell.—An electric bell which is rung by the alternate attraction and release of a polarized armature at the poles of an electromagnet.

Double Pole Cut Out.—A cut out which acts at once on both the positive and negative leads in an electrical circuit.

Double Pole Safety Fuse.—A double pole *cut out.*

Double Pole Switch.—A heavy switch which controls both leads of a circuit simultaneously.

Double Ported Valve.—A type of slide valve in which steam is admitted through two steam ports at each end of the cylinder face, thus reducing the travel of the valve.

Double Pull-over.—A form of trolley hanger designed to suspend the trolley wire at a curve, provided with two extension lugs for the attachment of strain wires; a *double* pull-over.

Double Reduction Gear.—A gearing sometimes employed in street car motors, in which the speed of the armature is reduced twice by two pinions and two spur wheels.

Double Reflection Tube.—An X-ray tube provided with two anti-cathodes for producing the rays by means of an alternating current.

Double Refraction.—A property possessed by many transparent crystalline substances, in virtue of which a ray of light is split into two in passing through them.

Double Refraction, Electric.—The property sometimes acquired by certain transparent crystals of dividing a ray of light into two when the crystal is influenced by an electric field.

Double Riveted.—A riveted seam in boiler making, etc., where the rivets are arranged in two parallel rows.

Double Seat Valve.—One employed to control alternate passageways in a pipe, having a seat upon either opening. A well-known instance is the valve employed in many small steamers, so that the steam from auxiliary engines may be directed either to the atmosphere or to the condenser, the controlling valve being provided with a seat on each passage, so that either may be closed at will.

Double Shackle.—A form of swinging telegraph insulator carrying two insulators joined by a shackle arrangement, for use at points where a bend occurs in the line.

Double Shear.—A rivet or bolt is said to be in double shear when it passes through three thicknesses of material, thus exposing its cross section to shearing action in two places, giving each unit double the resisting power it possesses when in single shear or uniting two thicknesses. The accepted standard of boiler riveting is to account a rivet in double shear to possess 1.75 the strength of single shear.

Double Shed Insulator.—A line wire insulator having a deeply indented rim, producing two flanges or "petticoats" separated by an air space for increasing the path of leakage; a *double cup insulator.*

Double Style Printing Receiver.—A Morse telegraphic receiver equipped with two points, one to indicate the dots and the other the dashes upon the paper strip.

Double Successive Contact Key.—A contact key adjusted so as to close two circuits in succession.

Double Tandem.—A type of engine, employed more especially in textile factories, where a uniform turning effort is important. The engine is arranged as a cross compound, but a tandem pair of high and low pressure cylinders drive each crank.

Double Tapper.—In single needle telegraphy, the signaling key, consisting essentially of two horizontal levers normally resting against a metal strip joined to the zinc pole of the battery, while at the other end another strip connects with the plus pole. By depressing the "line" key or the "earth" key, currents may be sent out through the circuit in either direction as desired.

Double Telegraphic Transmission.—The transmission of two messages at once over a single wire.

Double Telegraphy.—A term sometimes applied to *duplex telegraphy.*

Double Throw Switch.—A knife switch which may be thrown over into either of

two opposite sets of contacts; a *throw-over switch.*

Double Touch Magnetization.—A method of magnetizing a steel bar. The bar to be magnetized is placed upon two other bar magnets with its N pole resting upon the S pole of one, and its S pole upon the N pole of the other. With two other magnets, one in each hand and holding the two unlike poles together, stroke the bar beginning at the middle and drawing them away from each other toward the ends. The process should be repeated about ten times on each side.

Double Transmission.—The transmission of two messages along the same wire at the same time in opposite directions, as in duplex telegraphy.

Double Transmitter for Engine Telegraph.—A transmitter employed on a twin screw steamship for signaling from the bridge to both engines at once.

Double Trolley.—In a double overhead system, two trolleys on a single car, one connecting with the positive conductor and the other with the negative, thereby forming a metallic circuit.

Double Trolley System.—A system of electric traction in which the trolley wires are used to form a metallic circuit through two trolleys on each car.

Double Truck Car.—A long car resting upon two trucks, one near each end, as distinguished from small sized cars supported by a single truck under the middle of the car.

Double Vibration.—A double alternation, complete cycle of vibration, or *to and fro motion*, as in the alternating current cycle.

Double Winding.—An armature winding consisting of two independent insulated coils, each joined to alternate segments of the commutator, thereby dividing the current between the coils, and reducing the inductance in the circuit.

Double Wire Circuit.—A metallic circuit completed through two wires.

Double Wire Cleat.—A cleat suitable for fastening two wires at a time to a wall or ceiling.

Double Wire Moulding.—A moulding provided with two channels or grooves for supporting two wires.

Double Wire Telephone System.—A telephone system in which each subscriber's line is a separate metallic circuit employing two wires.

Double Word.—A word of such length as to be accounted for as two words in telegraphic messages.

Double Wound Wire.—An insulated wire having a double covering of insulating winding.

Douche, Electric.—A spray or shower of electrified water for medicinal purposes.

Dowel.—1. A pin of wood or metal inserted in the edge or face of two boards or pieces, so as to secure them together.

2. A small peg to attach planks edgewise, as in a cask head.

3. A plug put in a deck to cover a bolthead.

Downcomers.—In steam engineering, pipes fitted in water tube boilers to provide downward circulation, generally to mud drums. Also called *down flow pipes.*

Down Contact of Switch.—An electrical contact produced by moving a switch downward.

Down Lines.—A telegraphic term applied in Great Britain to the lines which lie in the direction remote from the chief station of the circuit, as opposed to *up lines.*

Down Side.—A telegraphic term applied in Great Britain to the side of a circuit away from the chief station, as distinguished from the *up side.*

D. P. Cut Out.—Abbreviation for double pole cut out.

D. P. Switch.—Abbreviation for double pole switch.

D. Q.—A signal in submarine telegraphy to indicate the point of separation between the address and the message itself.

Draft Tube.—In hydro- electric power stations, an air tight suction tube fitted to reaction turbines. Several types of these latter may be placed as much as 30 feet above the tail water, if this pipe be fitted, so that the weight of the column of water within it balances part of the atmospheric pressure, and the difference of pressure during the flow through the turbine is the same as if the turbine were placed at the bottom of the fall.

Drag.—The act of drawing a grapnel along the sea bottom, for the purpose of hooking a submarine cable.

Drag of Magnetic Field.—The force exerted by a magnetic field upon a conductor carrying an electric current.

Drain Cock.—1. A small valve placed on engine cylinders at their lowest points or wherever pockets are liable to occur in the passages, so that accumulated water from condensation or other sources may be blown off. 2. A similar cock fitted for kindred purposes on anything containing or passing liquids.

Draw Bar.—The bar by which a locomotive is attached to its load.

Draw Bar Pull.—The pull which an electric locomotive applies to the draw bar, as distinguished from the power put forth by its motor.

Drawbridge Frog.—A form of trolley frog adapted to the point of connection with a drawbridge wire.

Drawing-in-and-out Conduit.—A conduit with ducts for underground wires, and conveniently arranged so that wires may be removed or inserted at will.

Draw Tongs.—A device for gripping a wire in overhead line construction in the operation of securing the needed tension.

Draw Vise.—A form of vise for gripping a wire in overhead line construction.

Drehstrom.—A German term for a rotating or *rotary current.*

Drifting of Needle.—A condition of a galvanometer needle in which it fails to indicate zero on the scale when not in operation, due to fatigue of the needle suspension or faulty construction.

Drill.—A drill driven by an electromagnetic motor, and having either a rotary motion for metals, or a percussion or reciprocating action for rocks. In the percussion drill the stock acts as the core of a pair of solenoids through which the current is sent alternately.

Drilling.—Boring by the application of the heat of the voltaic arc, or by an electrically operated drill.

Drip Loop.—Before a wire enters a building a downwardly extending loop is formed, the lower end of which is below the entrance point. Water gathering on the wire will drip from the loop.

Driven Circuit of Transformer.—The circuit of the secondary coil of a transformer.

Driven Coil of a Transformer.—A term sometimes applied to the secondary coil of a transformer.

Driven Pulley.—When two pulleys are working together, connected by a belt, the one which receives the motion from the other is called the driven pulley.

Driven Pulley of Dynamo.—The pulley upon the armature shaft.

Driven Shaft.—The shaft operated by the transfer of rotation from a driving pulley.

Driving Circuit of Transformer.—The circuit of the primary coil of a transformer.

Driving Coil of Transformer.—A term sometimes applied to the primary coil of a transformer.

Driving Current of Motor.—The electric current by which a motor is driven.

Driving Electromotive Force.—The electromotive force brought to act upon a circuit so as to produce a current in it; the impressed E. M. F.

Driving Gear.—A general term, signifying the gearing, belts, pulleys, clutches, shafting, etc., whereby motion is transmitted to a machine.

Driving Gear of Magneto.—In a magneto generator for telephone work, a gear wheel designed to engage a pinion on the armature shaft by means of which the armature may be made to rotate rapidly.

Driving Points.—Certain points upon the cover plate of an electric railway controller which indicate no resistance in series, and hence are the ones on which the car should be driven. They are cast longer than the others so that the motorman cannot mistake them.

Driving Pressure.—The electromotive force brought to bear upon a circuit so as

to create a current in it; the impressed E. M. F.

Driving Pulley.—That pulley upon a line shaft which imparts motion to the countershaft of a machine or a second line of shafting.

Driving Pulley of Motor.—The pulley upon a motor shaft by which power is delivered from the motor.

Driving Shaft.—The main shaft by which power is distributed from the central source.

Drop.—1. A device to attract the attention of a telephone operator using a switchboard having a drop annunciator, when a subscriber wants a connection. A pivoted drop shutter is connected to the armature of an electromagnet and held suspended until a current passing through the coil releases it, when it falls to a horizontal position displaying the number of the line; an annunciator drop.

2. A lessening or fall of electrical potential or electromotive force.

Drop Annunciator or Indicator.—An electromagnetic annunciator which drops a shutter indicating the location of a call or signal when a current passes through its circuit.

Drop Grate.—A panel or portion of a fire grate fitted on a hinge, so that it may be dropped to clear it of ash or clinker.

Drop of Magnetic Potential.—A lessening or weakening of magnetic potential.

Drop of Potential.—The loss of electric potential in a circuit due to the resistance of the conductors, equal, at full load, to the maximum current multiplied by the resistance; the fall of potential.

Drop of Voltage.—The fall of the value of the electromotive force in any part of a circuit.

Drop Tee.—A short piece of pipe having a lateral outlet, used to connect a line of pipe with a pipe at right angles with the line, and running *downward*, causing the water or steam exhaust to drop down.

Drop Trolley.—A trolley wheel and pole having a spring by which the trolley is set against the wire.

Dross.—1. The scum or extraneous matter of metals, thrown off in the process of melting.

2. An incrustation formed on metals by oxidation; rust; crust of metals; waste matter; any worthless matter separated from the better part.

Drowned Tubes.—Those generating tubes of water tube boilers which discharge into the steam drum below the water level.

Drum.—A spool or reel for carrying coils of wire.

Drum Armature.—A dynamo or motor armature shaped like a cylinder and having its coils wound longitudinally, or parallel to its axis.

Drum Armature Winding.—The method of arranging the coils upon a drum armature.

Dry Battery.—An electric battery made up by assembling a number of dry voltaic cells. The term is often applied to a single dry cell.

Dry Cable.—A term sometimes applied to a conducting cable composed of wires contained within a lead sheath and separated from each other by air and paper; a dry core cable.

Dry Cell.—A primary cell which does away with the liquid electrolyte, so that there is no danger of spilling. It requires no care, being thrown away when exhausted. The jar, usually of zinc, forms one electrode, and the other electrode of carbon, is suspended in the jar so as not to touch the zinc. The zinc is protected by layers of blotting paper, and the chamber is filled with a mixture of carbon, manganese dioxide and sawdust (or other absorbent) saturated with a solution of sal ammoniac. The top is sealed, and the entire cell is contained in a cylinder of pasteboard. The carbon is the positive electrode, and the zinc the negative.

Dry Core Cable.—Air space and paper core cables, consisting of wires contained within a seamless lead sheath, and separated from each other by air and paper.

Dry Distillation.—A variety of *destructive* distillation without the use of water or any volatile solvent.

Dry Gelatine Cell.—A voltaic cell having its electrolyte combined with gelatinous material forming a jelly-like mass; a form of *dry cell*.

Dry Pile.—In physics, a form of the voltaic pile, constructed without the use of a liquid, affording a feeble current, and chiefly useful in the construction of electroscopes of great delicacy.

Dry Steam.—Steam which contains no moisture. It may be either *saturated* or *superheated.*

Dry Transformer.—A transformer employing air instead of oil as the cooling agent.

Dual Electrolysis.—The chemical decomposition of both the metal and the liquid in which the metal is dissolved, which takes place during the electrolysis of a metallic salt.

Dual Ignition.—Two ignition systems for igniting the charge in an internal combustion engine, but not entirely independent, that is, having one or more parts in common; as, a battery and a magneto system both having one set of spark plugs in common.

Duct.—One of the channels in an underground conduit in which wires or cables may be run.

Dull Pickling.—In electroplating, a preliminary dipping of a metallic object to give it a dead surface so that after plating it will show a matt luster; matt dipping.

Dummy Moulding.—A moulding designed merely to furnish symmetry to a room in which other mouldings are provided for electric wires.

Duplex.—Double; twofold; working in two ways or by two parts at once; as, a duplex pump.

Duplex Balance.—In duplex telegraphy, a balance maintained between the main line and the artificial line, so that the action of the home transmitting instrument does not operate the home relays.

Duplex Cable.—A cable composed of two separately insulated conductors running side by side.

Duplex Circuit.—An electric circuit associated with duplex telegraphy.

Duplex Cut Out.—A safety fuse so adjusted that a new strip can be substituted as soon as one has been melted by an excessive current.

Duplex Diplex.—A term sometimes applied to quadruplex telegraphy, which is the combination of *duplex* telegraphy in which two messages are sent simultaneously in opposite directions over the same wire, and *diplex* telegraphy in which two messages are sent at the same time in the same direction.

Duplex Electrolysis.—A term sometimes applied to *dual electrolysis.*

Duplex Flat Cable.—A flat cable containing two separately insulated parallel wires.

Duplex Insulator.—A double insulator for a line wire.

Duplex Loop.—A pair of wires connecting a branch telegraph office with the duplex apparatus of the main office, so as to make the duplex system available at the branch office.

Duplex Pump.—A direct acting non-rotative steam pump, in which equal cylinders, either simple or tandem compound are arranged side by side; the piston rod of each engine being prolonged as the pump rod of the pump which it drives. The chief characteristic lies in the valve gearing, the steam valve of each pump being driven through an arrangement of levers and linkwork from the crosshead of its neighbor.

Duplex Telegraphy.—The simultaneous telegraphic transmission of two messages in opposite directions over the same wire.

Duplex Telephony.—The simultaneous telephone transmission of two messages in opposite directions over the same wire.

Duplex Transmission.—Transmission of two messages simultaneously in opposite directions over the same wire.

Duplex Wire.—A conductor made up of two distinct wires running parallel to each other.

Duplex Working.—The operation of duplex telegraphy.

Duration of Electric Discharge.—The length of time required to complete a disruptive discharge.

Dust Proof.—Said of various bearings or portions of mechanism, when they are

provided with caps, covers or diaphragms in such a manner as to exclude the dust.

Dust Proof Bearing.—One constructed with caps and guards of impervious material so that dust is excluded from the surfaces in contact; a necessary device with the moving parts of railway rolling stock, automobiles and vehicles, generally.

Dust Telephone Transmitter.—A very effective form of transmitter in which carbon "dust" or granules, held between two conducting plates, are used as the variable resistance medium; a multiple contact carbon transmitter.

Dusty Gases.—A dangerous mixture, the cause of violent explosions in mines, flour mills and grain warehouses. Air filled with coal dust, etc., which in itself is too small in quantity to induce explosion, becomes explosive on the addition of still smaller proportions of combustible gas.

Dutchman.—A piece "fitted in" to restore a worn part or to hide a defect.

Dutch Metal.—An alloy composition of eleven parts copper to two of zinc, forming the most malleable of alloys.

Duty.—In mechanics, the work performed by an engine, especially a steam pumping engine, as measured in foot pounds, for a certain quantity of fuel or dry steam consumed.

Duty of Pumps.—This indicates the measurement of the work performed by pumps; "duty trials" are careful tests of the work done by the larger pumping engines for a certain quantity of fuel or dry steam consumed.

D Valve.—A name given to the common slide valve, as its sectional appearance is not unlike the letter D.

Dyad.—An atom, radical, or element having a capacity to unite with two atoms of hydrogen; a *bivalent* or *divalent element.*

Dyad Atom.—An atom having the valency, or combining power, of two units, i. e., of two atoms of hydrogen.

Dynamic Electricity.—A term applied to electricity in *motion,* as distinguished from *static* electricity, or electricity at rest; also called *current electricity.*

Dynamic Head.—In hydraulics, a head usually expressed in pounds per square inch, representing both the pressure due to the elevation to which the water is pumped, and that due to friction of the water in the pipes.

Dynamic Induction.—Magnetic induction produced in a body by a moving magnetic field, or in a moving body by a stationary magnetic field, or in a moving body by a field moving at a different rate.

Dynamics.—That branch of mechanics which treats of the action of forces producing motion in bodies; the science of moving forces; opposed to *statics.*

Dynamo.—A machine for converting energy in the form of mechanical power into energy in the form of electric currents, by means of electromagnetic induction. The dynamo in its simplest form consists of: (1) an armature, which in revolving induces electromotive forces in the copper conductor wound upon it; (2) a field magnet, which provides a field of magnetic lines, to be cut by the armature conductors as they revolve; (3) the pole-pieces; (4) the commutator or collector; (5) the collecting brushes that rest on the commutator cylinder and take off the current of electricity generated by the machine. Dynamos are classified as (1) direct current dynamos, and (2) alternating current dynamos. Those of the first class are subdivided with respect to their winding, as: (1) series wound; (2) shunt wound; (3)compound wound; each type having its particular usage.

Dynamo Armature Coils.—The armature windings of a dynamo.

Dynamo Battery.—Several dynamos acting together as one electric source.

Dynamo Brush Holders.—Adjustable clutches for holding the commutator brushes of a dynamo.

Dynamo Brush Trimmer.—A device for trimming the worn contact edges of commutator brushes.

Dynamo Changing Switch.—A switch for changing a dynamo from one circuit to another.

Dynamo Electric Generator.—A more precise term used to denote a *dynamo*; also called a dynamo electric machine.

Dynamo Frame.—The metal body of a dynamo, exclusive of the bearings and base, but including the pole pieces.

Dynamograph.—1. A name given to a telegraph that records messages in typewritten character at both ends of the line.

2. An electrical instrument for registering the work put out by any kind of machine.

Dynamometer.—A name given to instruments of various kinds for measuring the amount of energy expended in work.

Dynamometric Wattmeter.—A name given to a variety of electro-dynamometer in which the fixed and movable coils constitute two separate circuits, the *ampere* wire being thick and of low resistance, and the *volt* wire thin and of high resistance.

Dynamo Pole Changer.—A duplex or quadruplex telegraph transmitter provided with an automatic switch or contact breaker for reversing the direction of the current.

Dynamo Power.—The power a motor may possess to act as an electric generator.

Dynamo Regulator.—A rheostat for regulating the action of a dynamo.

Dynamo Resistance Box.—A form of dynamo regulator.

Dynamo Standards.—The supporting parts of a dynamo.

Dynamo Terminals.—The principal terminals on a dynamo connected with the external circuit.

Dynamotor.—A combination of dynamo and motor on the same shaft, one receiving current and the other delivering current, usually of different voltage, the motor being employed to drive the dynamo with a pressure either higher or lower than that received at the motor terminals. In one form two armatures are mounted on one shaft in a single field or in separate fields; one is a motor armature driven by the original current; the other generates new current. This is a "motor-dynamo", and it can transform continuous currents up or down. Another form of dynamotor is called the continuous alternating transformer. This is arranged so as to change a continuous into an alternating current or the reverse.

A motor-dynamo, rotary converter, or continuous current transformer.

Dynamotor Windings.—The windings upon the armature of a dynamotor.

Dyne.—The force which, acting on a mass of one gram for one second, imparts to it a velocity of one centimeter per second. The C. G. S. unit of *force.*

Dyne Centimeter per Second.—The C. G. S. unit of *activity.*

Dyne-cm.—Abbreviation for dyne-centimeter or *erg,* the C. G. S. unit of *work* or *energy.*

Dyne-cm².—Abbreviation for dyne-per-square-centimeter.

E.—1. In electrical engineering, an abbreviation for *earth*.

2. A contraction sometimes used for electromotive force, as in the formula for Ohm's law:

$$C = \frac{E}{R}$$

Ear.—An insulating device for supporting a trolley wire from the suspension span wire; a trolley ear.

Early Cut Off.—In steam engineering, a term relating to the ratio of the expansion of steam in an engine cylinder. Any cut off shorter than one-half the stroke may be properly termed early

Ear Piece.—That portion of a telephone receiver designed to rest against the ear of the listener.

Earth.—1. The ground considered as a medium for completing an electric circuit.

2. That portion of the ground used to complete a circuit.

3. A fault in a telegraph line due to the accidental contact of a part of the circuit with the ground or with conductors leading to it.

Earth Battery Current.—A slight electric current produced between the two earth plates at the ends of a telegraph circuit.

Earth Cell.—A voltaic cell made up of a voltaic couple sunk into moist earth; the moisture of the earth serving the purpose of the electrolyte.

Earth Circuit.—1. An electric circuit which is completed by the use of the ground as a part of the circuit; a *ground circuit*.

2. In ignition of internal combustion engines, the term "to ground" means: *to the metal of the engine;* the word ground was originally applied to the telegraph circuit where the earth is used as the return conductor.

Earth Circuited Conductor.—A conductor forming a part of an earth circuit.

Earth Coil.—A coil of wire rotating upon an axis at such an angle as to generate an electromotive force by cutting the lines of force of the earth's magnetic field.

Earth Connection.—A connection made between any electrical circuit or instrument and the earth.

Earth Currents.—1. Electric currents flowing through the ground, due to natural difference of potential.

2. Slight currents produced by the two earth plates of a telegraph line.

3. Currents due to different potentials of the earth's surface flowing over electric circuits, especially in submarine cables, where the working of the cable is seriously affected by them.

Earthed.—An electrical connection made to the earth; *grounded.*

Earthed Neutral.—In transformer practice, the grounding of the middle or neutral point of the secondary winding of the transformer in order to reduce fire risk in case the primary should become accidentally grounded; also called *grounded neutral.*

Earthenware Conduit.—A conduit for underground or other concealed wiring, made of glazed earthenware or clay.

Earth Grounded Wire.—A wire forming a part of an earth circuit.

Earthing.—The act of making electrical connection to earth.

Earthkin.—A magnetized sphere of steel or magnetite having a distribution of magnetism similar to that of the earth; a *terella.*

Earth Magnetic State.—That condition of the earth by virtue of which it possesses magnetic attraction. The intensity of the earth's magnetic force at any place is the force with which a magnet pole of unit strength is attracted.

Earth Plates.—1. Metal plates embedded in the earth at the terminals of telegraph

or other circuits for the purpose of grounding the circuit.

2. In overland wireless telephony, metal plates buried in the ground, forming the terminals of the system.

3. In the installation of lightning arresters, a sheet of copper or iron some 10 sq. ft. in area and at least ½ in. thick, buried deep enough to lie in damp soil, with a layer of powdered coke placed above and below it.

Earth Potential.—The electric potential of the earth considered as a large conducting sphere. This is due to a positive charge residing near its surface, but, as a positive charge generates an equal negative charge, the earth's potential, due to both charges, equals zero.

Earth Return.—The earth considered as the return path of an electric circuit; *ground return.*

Earth's Field.—The magnetic field produced by the earth's magnetic poles.

Earth's Flux.—The lines of magnetic force existing in the earth's magnetic field.

Earth Wires.—The wires by which a grounded circuit is connected to the earth plates.

Earthwork.—The operations connected with excavations and embankments of earth in preparing the foundations of buildings.

Easement.—A privilege secured from a property owner for the erection upon his place of poles or other appliances in electrical construction.

Easing Gear.—An arrangement of levers, etc., fitted to one safety valve of each boiler on a battery, whereby the engineer may ease the pressure when necessary.

Ebonite.—A hard black compound of india-rubber and sulphur, having high insulating properties and considerable value for generating frictional electricity; *vulcanite.*

Ebullition.—The rapid production of vapor in the mass of a liquid, usually called boiling.

Eburine.—An imitation of ivory made variously, as of bone dust and albumen.

Eccentric.—A disc, having its axis of revolution out of its center of figure, used for obtaining a reciprocating or alternate motion from a circular one, especially in the valve gear of steam engines; an eccentric wheel. The motion derived is that of a crank having the same throw; it is a crank pin which is so large that it embraces its shaft and dispenses with arms.

Eccentric Circle.—A term applied to the mechanical movement which constitutes the eccentric strap and connections; largely used to obtain reciprocal from rotary motion in steam engines, pumps, etc.

Eccentricity.—The distance from the center of a figure or revolving body to the axis about which it turns. In the eccentric used in engineering, this distance is equal to *one-half* the *throw.*

Economic Coefficient of Dynamo.—1. A number expressing the ratio between the useful output of a dynamo and the mechanical energy absorbed in driving it.

2. The ratio between the useful output of a dynamo and the total electrical energy generated by it.

Economiser.—An arrangement of tubes placed in the uptake or flues of a boiler serving as a feed water heater, thus effecting economy by extracting further heat from the furnace gases after they have passed through the boiler itself and before they are discharged by the chimney. In connection with stationary boilers, the tubes of the economiser are vertical; they are kept clean by ring scrapers continually traveling up and down them, a small engine being provided for driving the scraper mechanism. In certain water tube boilers, the economiser consists of a series of elements similar to that of the boiler proper, so that it really constitutes a second boiler.

Economy Coil.—A combination of a choking coil and transformer employed with alternating current arc lamps when the supply voltage is greatly in excess of that required by the lamps.

Eddy Current Loss.—The loss of electrical energy suffered by a dynamo or other electrical apparatus on account of the existence of eddy currents.

Eddy Currents.—Induced electric currents occurring when a solid metallic mass is rotated in a magnetic field. They consume a large amount of energy and often occasion harmful rise in temperature. The pole pieces, field magnet cores and armature of dynamos and motors are specially subject to these currents; also called *Foucault currents,* from the name of their discoverer.

Eddy Displacement Currents.—Eddy currents assumed to be present in a dielectric subjected to displacement currents.

Edgewise Instrument.—A form of electrical measuring instrument designed to economize space upon the switchboard, having instead of a flat dial, a dial with a vertical scale in the form of an arc along the curved edge of the instrument case, which is mounted in such a way as to project from the face of the board.

Edgewise System.—A system of switchboard construction for a large central station, designed to economize space and to enable one person to supervise all the switchboard apparatus; it provides that all the instruments shall stand at right angles, or edgewise, to the switchboard face, and that all the appliances belonging to any one circuit shall be erected one above the other.

Edgewise Winding.—A form of coil for winding field magnets in which bare copper strap bent edgewise is laid on with sheet insulation inserted between turns, while the outer surfaces are left unprotected in order that the exposed edges may radiate heat.

Edison Chemical Meter.—An electrochemical type of ampere hour meter once largely used, but now superseded by the recording wattmeter. The Edison meter consists of one or more pairs of cells connected in shunt to the circuit. Each cell is made up of a glass jar containing two zinc plates held at a fixed distance apart by hard rubber spacers and immersed in a solution of zinc sulphate. After a certain period, the ampere hours of current that have been consumed are measured by the gain in weight of the negative plate due to electrolytic deposit.

Edison Effect.—A continuous electric discharge which takes place when a metal plate is placed near one of the terminals of an incandescent lamp filament.

Edison-Lalande Cell.—A form of voltaic cell having a low resistance and little polarization. It consists of an amalgamated zinc plate and a compressed cake of copper oxide placed in a very strong solution of caustic potash.

Edison Storage Battery.—A bimetallic cell developed by Edison with special reference to the needs of electric automobiles. The active material of the positive plate is peroxide of nickel and that of the negative plate is finely divided iron, the material being held in flat stamped shallow steel boxes which are inserted into rectangular openings punched into a thin nickel plated steel grid. The electrolyte is a twenty per cent. solution of caustic soda.

Edison, Thomas Alva.—Born 1847. An American inventor, famous for his experiments in applied electricity. He began life with newspaper work which he soon abandoned for telegraphy, making many original inventions in duplex systems of operation. After a varied experience in that line he came to New York in 1871 where his talents were recognized and he had opportunity to profitably develop his ideas. The duplex telegraph was made a success the following year, and two years later the quadruplex; and thereupon he began manufacturing on a large scale for the Western Union Telegraph Co. In 1876 he gave up his factory, and established his experiment station at Menlo Park, N. J., where for several years he worked upon the problem of the incandescent electric light, exhibiting a successful bamboo filament lamp in Paris in 1881. He invented the phonograph in 1878. He superintended the construction of the first incandescent lighting station in New York in 1882. Moving his laboratory to Orange, N. J., he established there a large plant for electrical experiment and invention, and as a result of his labors there he has taken out 400 patents. Among his inventions may be further named: a type of dynamo, a microphone, the chemical electric meter, an electric pen, the mimeograph, the magnetic ore separator, dead beat galvanometer, the electric torpedo, a telephone transmitter, and a storage battery. His chief fame rests with his development of the telegraph, his invention of the incandescent lamp and the phonograph.

Edison Tubing.—A built-in underground system of laying electric conductors in the Edison three wire system of electric distribution.

Ediswan.—A trade name for incandescent lamps and other electric apparatus largely used in Great Britain, which embody inventions of Edison and Swan.

E. E.—Abbreviation for electrical engineer, a degree conferred by technical schools upon graduates who have satisfactorily completed the course in electrical engineering.

Eel, Electric.—An eel found in South American waters capable of giving violent electric shocks. It is the most powerful of electric fishes.

Effective Conductance.—The ratio of the energy component of current to the total E. M. F. in an alternating current circuit.

Effective Electromotive Force.—The effective value of the E. M. F. taken as the

square root of the mean square of the full alternating current wave.

Effective Heating Surface.—The part of the shell or tubes of a steam boiler which has water on one side and fire or hot gases on the other.

Effective Horse Power.—The amount of useful work which a steam engine is capable of performing. It is the difference between the indicated horse power and that required to drive the engine when it is running unloaded. It is equal to the *brake horsepower.*

Effective Reactance.—The ratio of the wattless component of E. M. F. to the total current in an alternating current circuit.

Effective Resistance.—The ratio of the energy component of E. M. F. to the total current in an alternating current circuit.

Effective Starting Current.—The value of the starting current of a motor as indicated on the ammeter.

Effective Susceptance.—The ratio of the wattless component of current to the total E. M. F. in an alternating current circuit.

Effective Value of Alternating Current.—That value which squared and multiplied by the resistance, gives the mean power; or, the root of the mean value of the squares of the momentary values of the current; also called virtual voltage, and root mean voltage.

Effective Value of E. M. F.—In electrical measurements, the square root of the mean square value of the full alternating current wave.

Efficiency.—The ratio of the net power output of an apparatus to its gross power input; in a *storage battery*, the efficiency may be regarded as the ratio of the energy output to the energy intake in a normal cycle; in an incandescent lamp, it is the ratio of its mean spherical candle power to the watts consumed.

Efficiency, Electric.—In a dynamo the electric energy delivered by the machine, divided by the total electric energy produced.

Efficiency of Conversion.—The ratio between the energy delivered by a dynamo in the form of electric currents, to the mechanical energy absorbed by the machine.

Efficiency of Distribution.—The ratio of the electrical energy distributed to consumers from an electric source, to the energy generated at the source.

Efficiency of Dynamo.—The ratio of the volts delivered at the terminals of a dynamo, to the total volts generated by the machine.

Efficiency of Electric Lamp.—Frequently described as the ratio of the power absorbed to the light emitted; that is, proportional to the watts per candle power; but, properly speaking, it is the ratio of the light emitted to the power absorbed.

Efficiency of Electric Motor.—The ratio of the mechanical energy developed by a motor to the electrical energy consumed in driving it.

Efficiency of Primary Cell.—The ratio of the electric energy given out at the poles of a voltaic cell to the energy expended in performing electrolysis within it.

Efficiency of Radiation.—The ratio between the luminous rays and the total radiation emitted by a radiating body.

Efficiency of Storage Cell.—The ratio of the output to the input of a secondary cell; the *quantity* efficiency being the relation of the ampere hours given out to the ampere hours put in; the *energy* efficiency being the relation of the watt hours given out to the watt hours put in.

Efficiency of Transformer.—The ratio of the power taken from the secondary of a transformer to the power supplied to its primary.

Efflorescence.—1. The gradual decomposition of crystalline salts from loss of water, resulting in a whitish powder.

2. The deposit which is the result of this change, especially upon the surface of vessels containing a solution of salts.

Effluvium, Electric.—A stream of minute particles formerly supposed to be given off from a magnet or electrified body. During the early history of the science all electrical phenomena were attributed to this imaginary "effluvium."

Efflux.—The rate of outflow of a liquid from an opening in the vessel containing it.

Effort.—In mechanics, a force which acts upon a body in the direction of its motion.

Effusion.—In chemistry, the escape or flow of a gas through a thin sheet or membrane into a vacuum.

Egg, Electric.—A vacuum tube or chamber resembling an egg in shape, for the purpose of exhibiting luminescence upon the passage of an electric current through it.

E. H. P.—Abbreviation for electrical horse power.

Eight Bend.—In steam fitting, a bent pipe whose length equals one-eighth of the circumference of the circle to whose radius the curve of the bend is struck.

Ejector.—An apparatus, consisting of a series of conical nozzles, whereby a jet of steam or compressed air propels a stream of liquid or fluid. The principle is the same as that of the *injector*, but the *ejector* always delivers into a space with but little pressure upon it, hence the differences in the design. Ejectors are fitted as emergency bilge pumps aboard ship, most warships having one in each compartment; and they are employed on railways to actuate the vacuum brake.

Elastic.—Having the quality of elasticity. Said of a body which has the property of recovering its original size and shape after it has become distorted by the application of force.

Elastic Fluids.—Those which have the property of expanding in all directions on the removal of external pressure; as, the air, gases, vapors.

Elasticity.—The property possessed by a solid body of resuming its original shape upon removal of any force which has modified its form by stretching, compression, twisting, etc. In a fluid this property permits it to assume its original volume after compression.

Elasticity, Electric.—The property of a dielectric in virtue of which the passage of a displacement current due to the electric stress is arrested; it is equal to the electric stress divided by the electric strain.

Elastic Limit.—The extent to which a body may be deformed or strained, and still retain the power of completely recovering its original shape when the stress is removed. When the elastic limit is exceeded, the body acquires a permanent alteration of form, or "set".

Elastic Strength.—The greatest strain or stress which a body is capable of sustaining before its *elastic limit* is reached.

Elbow.—A pipe fitting, consisting of a short bend through an angle of 90°, though others are obtainable which give an angle of 45°. Elbows are sometimes made with a sharp turn, being the intersection of two cylinders at right angles.

Elbow Connection.—A connection having a bend or an angle not far from 90°.

Elbow Connector.—A device for joining two conductors in an elbow connection.

Electrepeter.—An instrument for changing the direction of an electric current; a *pole changer*.

Electrically Controlled Clock.—A clock whose movements are controlled or regulated by electricity.

Electrical Resistance Pyrometer.—This instrument is employed to measure heat, depending upon the increase of resistance in a platinum wire as the temperature rises; this rate of increase is nearly constant and the instrument is so sensitive that it can record changes of .00001° C. over a very great range. Another method used in metallurgy is the thermo-electric couple, consisting of two wires of dissimilar metals twisted together in series in connection with a galvanometer, the latter deflecting according to the E. M. F. at the junction, and graduated to a very wide range.

Electrician.—A person who is versed in the knowledge and practice of electricity.

Electricity.—The name given to an invisible agent known only by its effects and manifestations, as shown in electrical phenomena. Electricity, no matter how produced, is believed to be one and the same thing. The terms frictional electricity, magneto electricity, etc., though convenient for distinguishing their origin, have no longer the significance formerly attributed to them as representing different kinds of electric force.

Electricity Meter.—An instrument, depending for its action on the chemical or the electromagnetic properties of an electric current, for the purpose of measuring electric supply delivered to a consumer in a distribution system.

Electricity of Opposite Sign.—In electro-statics, electric charges in which positive and negative electrification are opposed to each other. Bodies so charged *attract* each other.

Electricity of Same Sign.—In electrostatics, electric charges which are all positive or all negative, as distinguished from electricity of *opposite* sign. Bodies so charged *repel* each other.

Electrifiable.—Capable of becoming electrified, or charged with electricity.

Electrification.—1. The act of charging with electricity.
2. The state of being charged with electricity.

Electrified Body.—A substance or body charged with electricity.

Electrify.—To produce an electric charge.

Electrine.—1. Pertaining to or resembling amber.
2. Made of the alloy *electrum.*

Electrization.—The act of charging with electricity, or the state of being charged with electricity; electrification.

Electro-anæsthesia.—Causing a loss of sensibility to pain by the application of electricity.

Electro-ballistics.—Electricity in its application to the determining of the velocity and force of flying projectiles.

Electrobath.—The liquid which holds in solution the metal to be deposited by electroplating; *the bath.*

Electro-biologist.—A person versed in the science of electro-biology.

Electro-biology.—That branch of electricity which treats of the electric phenomena developed in living beings, either mankind or animals.

Electro-bioscopist.—A person versed in electro-bioscopy.

Electro-bioscopy.—The application of an electric current to the nerves or muscles of the human body to determine whether or not life is extinct in cases of doubt.

Electro-brassing.—Depositing a coating of brass in electroplating; *brassing.*

Electro-calorimetry.—The operation of measuring the heat developed by an electric current in a conductor or circuit.

Electro-capillarity.—The influence of electricity upon capillarity.

Electro-capillary Phenomena.—Capillary forces caused to act by the action of an electric current through a capillary tube; this principle is utilized in the construction of the capillary electrometer.

Electro-capillary Revealer or Relay.—In wireless telegraphy, a variety of wave detector and relay based upon the principle that the capillary attractions at the point of contact between mercury and dilute sulphuric acid undergo modifications upon the passage of an electric current.

Electro-chemical.—Relating to electro-chemistry.

Electro-chemical Accumulator.—A term sometimes applied to the *storage battery.*

Electro-chemical Decomposition.—The breaking up of a molecule of matter into its separate *ions* or *atoms* by the action of electrolysis.

Electro-chemical Equivalent.—The weight in grams of an element liberated through electrolysis by one coulomb of electricity. The electro-chemical equivalent of hydrogen is .000010352, and that of any other element may be obtained by multiplying this number by the chemical equivalent of that element.

Electro-chemical Filtration.—A term sometimes applied to electric *osmose.* When a strong electric current is passed through certain liquids in which a porous partition is placed between the electrodes, a part of the liquid is carried through the membrane in the direction of the electric flow.

Electro-chemical Meter.—An electric meter which measures the current by the amount of chemical change it causes in a metallic solution; an *electrolytic meter.*

Electro-chemical Series.—The grouping of the chemical elements in a list, usually beginning with oxygen and ending with potassium, so that, with reference to their electrical affinities, each one is electro-negative to all following it in the list, and electro-positive to all preceding it.

Electro-chemical Telephone.—A term sometimes applied to the *electro-motograph.*

Electro-chemist.—An expert in electro-chemistry.

Electro-chemistry.—That branch of the science of electricity which treats of the influence of electricity in producing chemical changes. All electro-chemical operations are performed either by the analytical property of electrical energy when passed through an electrolyte, or by the heat which is produced when a current of electricity is passed through a conductor which is not an electrolyte.

Electro-chromic Rings.—When a solution of lead is subjected to the passage of an electric current, a film of lead peroxide forms upon the anode, and if the anode be a plate of polished metal placed horizontally in the liquid beneath a platinum wire, as a cathode, the deposit forms rings of rainbow colors. These rings are known as Nobili's rings or metallochromes.

Electro-chronometric Counter.—The mechanism in a series of electric clocks by which the principal clock operates and regulates the subordinate clocks.

Electro-contact Mine.—A submarine mine, employed in naval warfare, which is designed to explode at the contact of a passing ship which completes the circuit of an electric battery on the shore.

Electro-coppering.—Depositing copper by electroplating.

Electro-crystallization.—Crystallization occurring during electrolysis.

Electro-culture of Plants.—The use of electricity to promote artificially the growth of plants.

Electrocution.—A term often applied to the method of inflicting capital punishment by passing a current of electricity through the body of a criminal.

Electro-deposit.—A coating of metal deposited by electroplating.

Electro-deposition.—The process of coating metallic articles with a film of another metal by the aid of electrolysis. The article to be treated is suspended in a bath containing an acid solution of the metal to be deposited, the positive wire of an elecric battery or dynamo being attached to an *anode* or mass of the same metal as that in the solution; the negative wire is connected to the object immersed. By the action of the electric current, the anode at the positive terminal is decomposed, and deposited upon the article attached to the negative pole.

Electro-deposits.—Metallic deposits made through the agency of electricity, as in the reduction of metal from ores, the casting of types, and electroplating.

Electrodes.—1. In electrolysis, the terminal plates in the bath; the plate by which the current enters the solution is called the *anode* and that by which the current leaves is called the *cathode.*

2. In a voltaic cell, the plates immersed in the exciting fluid or electrolyte.

3. In arc lighting, the carbons which form the terminals for the arc.

4. In electro-therapeutics, terminals for the curative applications of electricity.

Electro-diagnosis.—The application of electricity to the tissues of the human body in performing medical diagnosis.

Electro-diapason.—A tuning fork which is kept in vibration by electricity.

Electro-dynamic Attraction.—The attraction which electric currents exert upon each other.

Electro-dynamic Capacity.—A term sometimes applied to *self induction.*

Electro-dynamic Machinery.—The machines, apparatus and instruments concerned with electrical energy as produced by electric currents.

Electro-dynamic Repulsion.—The tendency of two electric currents flowing in opposite directions to repel each other.

Electro-dynamic Rotation.—A rotation produced in a liquid when an electric current is passed through it, while at the same time it is influenced by the induction of a current moving at right angles to it.

Electro-dynamics.—That branch of the science of electricity which is concerned with *the force* exerted by currents upon one another.

Electro-dynamometer.—An instrument including a fixed coil surrounded by a movable coil, for measuring the strength of an electric current by means of the attraction or repulsion exerted by one part of the circuit upon another part.

Electro-enamel.—An impregnating preparation for electric conductors. It is claimed to be an acid and moisture-proof varnish with good heat conducting and cementing qualities.

Electro-engraving.—1. An etching process in which a metal plate, which has been covered with a ground and etched, is subjected to the action of an electro-bath in order to cut deeper the lines of the design.
2. The name for an engraving made by this process.

Electro-etching.—A term sometimes applied to *electro-engraving.*

Electro-extraction of Ores.—The reduction of metals from their ores by means of electricity.

Electro-filtration.—The same as electro-chemical filtration or electric *osmose.*

Electro-fusion.—The fusion of metals by the electric current.

Electrogen.—A device for preventing corrosion and pitting within boilers in connection with surface condensers. A large ball of zinc is suspended in the water space of the boiler, to which are soldered copper wires, these being led to any part of the boiler where pitting has commenced. It is necessary to scrape the steel absolutely bright to ensure good metallic contact, and the wires should be secured by bright studs, nuts and washers; the temperature being generally too high for solder. Galvanic action set up in the boiler now attacks the zinc instead of the steel, as the former metal is electro-positive to the latter.

Electro-genesis.—In electro-therapeutics, the state of tetanoid spasm that occurs in muscles highly stimulated by electricity after the current is withdrawn.

Electrogeny.—Spasmodic contraction of the muscles of the limbs which occurs when an electric current passes through the nervous system; *tetanus.*

Electro-gilding.—Depositing a very thin coating of gold by electroplating.

Electro-gilt.—Gilded by the process of electroplating.

Electrograph.—A tracing, curve or record made by any recording electrical instrument.

Electrogravure.—A reproduction made by a special electrolytic process. A cast of the original to be copied is made in some porous material, and is then placed in a suitable electrolyte so that its surface is kept wet without being immersed. A metal disc laid upon the surface becomes the anode. The path from the cathode lying through the face of the cast, the metal disc becomes corroded at the points of contact, and this goes on until the disc bears an accurate reproduction of the object from which the cast was made.

Electro-kinetic Energy.—Electric energy at work; the energy of *electric flow.*

Electro-kinetics.—That branch of electricity dealing with electric currents or electricity *in motion*, as distinguished from electro-statics which treats of the properties of simple electrified bodies or electricity *at rest.*

Electro-kinetic Units.—The electromagnetic units, being a system of units based upon the attraction or repulsion between magnetic poles.

Electrolier.—A fixture for supporting a cluster of incandescent electric lamps.

Electrolier Arm.—A bracket by which an incandescent lamp is attached to an electrolier.

Electrolier Cut Out.—A cut out in the circuit of an electrolier.

Electrolier Switch.—A switch for turning on or extinguishing the lights of an electrolier.

Electro-lithotrity.—In surgery, the operation for the destruction of calculi in the bladder by electrolysis.

Electrolysis.—The decomposition of a chemical compound in solution, called the *electrolyte*, into its constituent elements, called *ions*, by the passage of an electric current through it. There are two kinds of ions, viz.: the electro-positive ons called *cations* and the electro-negative ions called *anions;* the former appear at the cathode and the latter at the anode. The number of ions liberated in a given time is proportional to the current strength. The current may be regarded as being carried through the electrolyte by the ions; since an ion is capable of carrying a fixed charge only of + or — electricity, any increase in the current strength necessitates an increase in the number of ions.

Electrolyte.—1. The liquid decomposed in electrolysis.
2. The exciting fluid of a voltaic cell.

Electrolytic Accumulator.—A term sometimes applied to the *storage battery.*

Electrolytic Assaying.—The application of electrolysis to the testing of metals to determine their purity.

Electrolytic Bath.—The chemical solution which is acted upon and broken up into its elements by the electric current, by the process of electrolysis.

Electrolytic Conduction.—The conduction of electricity through an electrolyte by means of electric charges carried by the ions separated by electrolysis.

Electrolytic Copper.—Copper that has been freed from impurities by electrolysis. Crude copper leaving the smelting works with certain percentages of impurities is refined by electrolysis so that electrolytic copper has more than 98 per cent. of the conductivity of pure copper, and is, therefore, largely used for copper wires in electric lighting and in electric machines.

Electrolytic Corrosion.—The corroding, by the action of electrolysis, of metal pipes or other bodies which lie in damp earth in the vicinity of electric currents.

Electrolytic Decomposition.—The breaking up of a molecule into its separate ions or atoms by the action of electrolysis.

Electrolytic Detector.—In wireless telegraphy, an extremely sensitive form of detector consisting of an electrolytic cell, with a minute anode of insoluble material such as platinum, and a larger cathode immersed in a suitable electrolyte. When oscillations arrive, the anode becomes depolarized and changes occur in the local current which act upon a telephone receiver, where the message is read.

Electrolytic Diaphragm.—A diaphragm or partition used in an electroplating bath.

Electrolytic Dissociation.—A term sometimes used for electrolytic decomposition.

Electrolytic Dynamo.—A continuous current dynamo that furnishes current for electrolytic processes.

Electrolytic Depilation.—The removal of hair by the electrolytic destruction of the roots.

Electrolytic Hydrogen.—Hydrogen that is freed from a compound by electrolysis.

Electrolytic Instrument.—Any instrument which depends for its action upon the electro-chemical effects of an electric current upon a solution capable of conducting electricity.

Electrolytic Interrupter.—A form of interrupter employed with induction coils, especially in X-ray work, consisting of a platinum needle point, introduced through a glass tube, as one electrode and a large sheet of lead as the other, immersed in dilute sulphuric acid. If these electrodes be connected through an inductance to a source of supply, the current in the circuit will be subject to rapid interruptions.

Electrolytic Lightning Arrester.—A form of lightning arrester designed for use in high-tension circuits. It is based on the characteristic of aluminum, as an electrode in a cell with carbon or other metal combined with a suitable electrolyte, of letting current flow freely in one direction but not in the opposite direction, while if both plates were of aluminum the action of the device becomes similar to that of the safety valve on a steam boiler. The arrester adapted from these characteristics consists of a large number of aluminum plates assembled in tray form, insulated from each other, and all containing the electrolyte, and the whole enclosed in a stoneware jar.

Electrolytic Meter.—A term sometimes applied to the electro-chemical meter.

Electrolytic Rectifier.—A form of rectifier based upon the property which an aluminum electrode has of letting electricity pass in one direction, but not in the other. One form employs a neutral solution of ammonium phosphate as the electrolyte, with aluminum as one electrode, and lead or polished steel as the other. Also called *aluminum cell rectifier.*

Electrolytic Refining.—The elimination of impurities from metals and chemicals by electrolysis.

Electrolytic Voltameter.—An instrument for measuring the value of an electric current by the action of electrolysis. It is a convenient means of calibrating direct reading electrical instruments. The measurement depends upon the amount of metal

deposited by the current passing through the electrolyte. The principal forms are the silver, copper and water voltameters.

Electrolyzable.—Capable of decomposition by the action of electricity.

Electrolyze.—To decompose a substance by the action of an electric current.

Electrolyzer.—That which performs electrolysis.

Electrolyzing Cell.—A term sometimes applied to an electrolytic cell.

Electromagnet.—A magnet produced by passing an electric current through an insulated wire conductor coiled around a core of soft iron, as in the fields of a dynamo or motor. *In such a magnet the magnetism is preserved only while the current is flowing through its coil.*

Electromagnetic.—Relating to electromagnets and electromagnetism.

Electromagnetic Ammeter.—A type of ammeter suitable for the measurement of either alternating or continuous current, with separate calibration for each. This form consists essentially of a coil and plunger, the magnetic pull working against gravity.

Electromagnetic Attraction.—The attraction exerted upon each other by unlike poles of electromagnets.

Electromagnetic Bell.—A bell rung by the attraction of an electromagnet; an *electric bell.*

Electromagnetic Blow Out.—A strong electromagnet provided in the controller of an electric car to blow out the arcs and sparks arising from the frequent disconnections made in the controller; otherwise the sparking might destroy the contacts and brushes; also called *magnetic blow out.*

Electromagnetic Brake.—A brake which is applied to a car wheel by the operation of electromagnets.

Electromagnetic Call Bell.—A call bell rung by the action of an electromagnet; an *electric bell.*

Electromagnetic Capacity.—A term sometimes applied to electromagnetic inertia or self-induction.

Electromagnetic Cut Out.—An automatic switch which opens a circuit by the action of an electromagnetic mechanism.

Electromagnetic Dental Mallet.—An instrument for hammering fillings into teeth, striking blows in quick succession by means of electromagnetic mechanism.

Electromagnetic Drill.—A drill worked by electricity for purposes of mining or rock boring; an *electric drill.*

Electromagnetic Eye.—A device consisting of a copper wire bent nearly into a circle, having a spark gap between its terminals, for the purpose of examining a field of electromagnetic radiations.

Electromagnetic Field.—The space which is supposed to be filled with electromagnetic lines of force.

Electromagnetic Flux.—The distribution of the lines of force through an electromagnetic field.

Electromagnetic Gyroscope.—A gyroscope driven by an electric motor.

Electromagnetic Helix.—A solenoid, or coil of wire, through which an electric current is passing while encircling a core of magnetic material; an electromagnetic solenoid or *electromagnet.*

Electromagnetic Impulse.—A pulsation conveyed to the ether from a conductor carrying a pulsatory current.

Electromagnetic Induction.—The tendency of electric currents to flow in a conductor when it is moved in a magnetic field so as to cut lines of magnetic force. Faraday discovered that if he took a wire, joined the ends and moved it rapidly in front of a magnet, a current would be induced in the wire. This action of the magnet is called electromagnetic induction. The current is called the induced current and it is upon this principle that all dynamo electric machinery is based, as well as induction coils, alternate current transformers, and other electrical appliances.

Electromagnetic Inertia.—A term sometimes applied to *self-induction* which is an inductive effect produced in a circuit by the magnetic lines of its own current cutting across other parts of the same circuit. This action produces an E. M. F. which opposes the current and retards it, so that the current behaves as if it possesses inertia.

Electromagnetic Intermitter.—An automatic contact breaker; a *magnetic vibrator.*

Electromagnetic Medium.—A medium exhibiting the phenomena of electromagnetism.

Electromagnetic Meter.—An electricity supply meter depending for its action upon the electromagnetic properties of an electric current. In this type the entire current may pass through the meter.

Electromagnetic Momentum.—The self-induction in a circuit, whereby an effort appears to be made to uphold the current when the circuit is first broken.

Electromagnetic Pop Gun.—An electromagnet having a tubular central portion containing a small free iron core which is forcibly projected when an electric current passes through the coils.

Electromagnetic Principle.—The principle of the action of the electric current discovered by Oersted and developed by Ampère, Arago, Davy and others. It is upon this principle that present day electrical engineering is based.

Electromagnetic Radiation.—The projection of electromagnetic waves into the ether by oscillatory discharges from an induction coil across a *spark gap.*

Electromagnetic Repulsion.—The repulsion exerted by two like electromagnetic poles against each other.

Electromagnetic Resonator.—A nearly complete circle or square of wire containing an adjustable spark gap, employed by Hertz to detect electromagnetic waves in his experiments which laid the foundation for the science of wireless telegraphy.

Electromagnetic Rotation.—An intensified manifestation of electro-dynamic rotation of a liquid when the acid is influenced by an electromagnet.

Electromagnetic Separator.—A machine for the collection of iron ores, in which a powerful electromagnet is used to separate particles of iron from foreign matter.

Electromagnetic Shunt.—In telegraphy, an electromagnet forming a shunt of high self-induction joined in parallel with the receiving relay. The resistance of the magnetic circuit is reduced by the poles being permanently closed by a soft iron armature. A current is produced in the coils of an electromagnetic shunt, in the opposite direction to the relay current, on making the circuit in the coils of a receiving relay; on breaking the circuit, a current having the same direction as the current in the relay is produced in the shunt coils.

Electromagnetic Solenoid.—An electric conductor bent into a long helix of many loops, through which a current of electricity is passing, and encircling a central core of magnetic material, forms an electromagnetic solenoid or an *electromagnet.*

Electromagnetic Strain.—The strain resulting from electromagnetic stress.

Electromagnetic Stress.—A force producing an electromagnetic strain due to the tension and compression existing in an electromagnetic field.

Electromagnetic Telegraphy.—The Morse system of telegraphy.

Electromagnetic Theory of Light.—A theory advanced by Maxwell that waves of light are electric waves of very short wave lengths and high frequency, and not mere mechanical motions of the ether as had been formerly supposed.

Electromagnetic Units.—A system of units based upon the attraction or repulsion between magnetic poles, employed to measure quantity, pressure, etc., in connection with electric currents.

Electromagnetic Vibrator.—On a secondary induction coil, a device for making and breaking the primary current with great rapidity when the battery is in the circuit. Its operation is as follows: when the battery is switched into the primary circuit, (a) the primary current flows and magnetises the core of the coil, (b) the magnetised core attracts the free end of the vibrator and breaks the primary circuit, (c) the magnetic attraction ceases and the vibrator springs back to its original position, which closes the primary circuit and the cycle begins again.

Electromagnetic Voltmeter.—A type of voltmeter in which the electrical pressure is indicated by a magnetic needle moving in an electromagnetic field.

Electromagnetic Waves.—Wave-like vibrations created in the universal ether by electrical disturbances; *electric radiation.*

Electromagnetism.—The phenomena which accompany the production of magnetism by electric currents.

Electromagnetization.—The imparting of magnetism to a substance by subjecting it to the influence of an electromagnet.

Electro-massage.—Massage of the body combined with the application of electricity.

Electro-mechanical Alarm.—An alarm whose mechanism is set in motion by electricity.

Electro-mechanical Bell.—A bell having its striking mechanism operated by a spring or weight combined with a release action performed by the agency of an electric current.

Electro-mechanical Indicator.—An indicator or drop having its mechanism thrown into action by an electric current.

Electro-medical.—Relating to the use of electricity in the practice of medicine; *electro-therapeutic.*

Electro-medical Apparatus.—Any set of instruments for the application of electricity in medical practice.

Electro-metallurgical Circuit.—An electric circuit which performs a metallurgical operation.

Electro-metallurgical Deposit.—The layer or coating of metal deposited upon a conducting surface in the process of electroplating.

Electro-metallurgical Galvanization.—A term sometimes employed for the process of depositing a metal over a conducting surface by electrolysis; *electroplating.*

Electro-metallurgy.—A general term covering the application of electro-chemistry to the industries; it includes: firstly, the reduction of metals from solutions of their ores, a process too costly for general application, but one useful in the accurate assay of certain ores, as, for example, of copper; secondly, the copying of types, plaster casts, and metal work by cathode deposits of metal; thirdly, the covering of objects made of baser metal with a thin film of another metal, such as gold, silver, or nickel. All these operations are included under the general term of electro-metallurgy.

In 1836 De La Rue observed that in a Daniell's cell the copper deposited out of the solution upon the copper plate which served as a pole took the exact impress of the plate, even to the scratches upon it. In 1839, Jacobi, Spencer, and Jordan independently developed out of this fact a method of obtaining, by the electrolysis of copper, impressions (in reversed relief) of coins, stereotype plates, and ornaments. A further improvement, due to Murray, was the employment of moulds of plaster or wax, coated with a film of plumbago in order to provide a conducting surface upon which the deposit could be made.

Electrometer.—An instrument, of which there are many forms, for measuring differences of electrical potential.

Electrometer Fatigue.—The exhaustion of the elastic suspension of an electrometer needle resulting in the failure of the needle to return to zero on the scale after deflection.

Electrometer Gauge.—A form of absolute electrometer employed in connection with certain types of electrometers for testing the potential of the needle connected with the inner coating of the Leyden jar belonging to the apparatus.

Electrometer Voltmeter.—A term sometimes applied to an electro-static voltmeter.

Electrometric or Electrometrical.—Relating to the electrometer, or to the measurement of electric potential.

Electrometry.—The art or practice of *electrical measurement.*

Electro-motion.—Mechanical action set up by electricity.

Electromotive Force.—The force which starts and maintains a current of electricity through a conductor; it is commonly measured in terms of a unit called the *volt.* It is abbreviated E. M. F. Unit E. M. F. is that pressure which forces one ampere of electricity through a resistance of one ohm. Thompson uses the term electromotive force as follows: "The term 'electromotive force' is employed to denote that which moves or tends to move electricity from one place to another. In this particular case it is obviously the result of *difference of potential* and proportional to it; just as in water pipes, a difference in level produces a pressure, and the pressure produces a flow as soon as the tap is turned on, so difference of potential produces electromotive force, and electromotive force sets up a current as soon as a circuit is completed for the electricity to flow through."

Electromotive Force of Induction.—The electromotive force set up in a circuit by the influence of induction.

Electromotive Force of Polarization.—The counter E. M. F. set up in a primary

cell by the polarization due to the formation of hydrogen bubbles upon the surface of the copper plate.

Electromotive Force of Self-induction.—The induced electro-motive forces in a coil combined to form an E. M. F., called the *counter* or *back* E. M. F., with a direction opposite to the main electromotive force of the circuit.

Electromotive Intensity.—The force which is exerted upon a unit charge of electricity.

Electromotive Series.—An arrangement of different metals in a series such that each one becomes positively electrified when placed in contact in air with the metal next below it in the series. Volta discovered this property and from his observations, the so called *Volta's law* has been formulated, that the difference of potential between any two metals is equal to the sum of the differences of potentials between the intervening metals in the contact series. The arrangement of the metals in the contact series is as follows:

+ Sodium	Tin	Gold
Magnesium	Iron	Platinum
Zinc	Copper	—Carbon
Lead	Silver	

Electromotive Source.—Any source from which an electric current arises, such as a dynamo or voltaic cell.

Electro-motograph.—An apparatus invented by Edison and consisting of a rotating cylinder of chalk moistened with caustic soda against which is pressed by a spring an arm carrying a metallic brush, and connected with a diaphragm producing constant tension: when an electric current passes through the point of contact at the surface of the cylinder, electrolytic action causes a change in the friction. This varying pressure is applied in a type of loud speaking telephone in which the pitch of the sound emitted varies with the friction.

Electro-motograph Telephone.—A loud speaking telephone constructed on the principle of the electro-motograph.

Electro-motor.—A term sometimes applied to a voltaic cell or battery.

Electro-muscular.—Relating to the effect of electricity upon muscular tissues.

Electro-muscular Excitation.—In electro-therapeutics, the effect produced upon the muscular tissues of the human body by the passage of electric currents through them.

Electron.—The positive or negative charge of the *ion*, considered as indivisible, and hence the smallest quantity of electricity conceivable. Electrons are atoms of electricity, and may be regarded as the elements of construction in the building up of atoms of matter. The electron theory is now advanced to account for the phenomena of light, the nature of cathode rays, radio-activity, and the constitution of matter itself.

Electro-necrosic.—Relating to death by electricity as a capital punishment

Electro-negative.—1. Possessing negative electrification.

2. Relating to those elements in electrolysis that appear at the anode.

Electro-negative Ion.—In electrolysis, the element which appears at the anode, or positive electrode; the *anion*.

Electro-negative Radical.—The electro-negative *ion*.

Electro-negatives.—The electro-negative ions.

Electro-nervous Excitation.—In electro-therapeutics, the effects produced upon the nerve fibres of the human body by the passage of an electric current.

Electro-nickeling.—Depositing nickel by *electroplating*.

Electro-optics.—That branch of electrical science which treats of the relation of electricity to light.

Electropathic.—Relating to electropathy.

Electro-pathology.—The use of electricity in the diagnosis of disease.

Electropathy.—The use of electricity in the treatment of disease; *electro-therapeutics*.

Electro-phanical.—Relating to death by electricity as a capital punishment.

Electrophobia.—Unreasonable fear of electricity.

Electrophone.—Any instrument for producing or transmitting sound by means of electricity, as a *telephone transmitter*.

Electrophor.—An abbreviation sometimes used for electrophorus.

Electrophoric Medium.—A term sometimes applied to a dielectric, which is an insulating or non-conducting medium that permits the influence of an electrified body to pass across it.

Electrophorus.—A simple instrument consisting of a plate of insulating material and a metal disc with a glass handle, devised originally by Volta for the purpose of illustrating electrostatic induction.

Electro-photometer.—An instrument for comparing sources of light by referring them to the light of an electric spark as a standard.

Electro-photo-micography.—The art of obtaining photographs of minute objects when enlarged by the microscope with the aid ot the electric light.

Electro-physiologist.—A person versed in electro-physiology

Electro-physiology.—The science of electric phenomena in animal and vegetable systems

Electropism.—The influence of electricity upon the direction of growth of vegetable organisms.

Electroplating.—The process of depositing a layer or coating of a rarer metal upon the surface of a baser, or of a metal upon any conducting surface, by electrolysis. The full details of the many processes for electroplating cannot be given on account of their length: the general principle includes a battery or other source of electric current. The battery has its positive plate connected to a rod extending across a trough or tank containing the plating bath. Suspended from the rod are anodes of gold, silver or copper, or whatever metal from which a deposit is desired. The other plates of the battery, or the negative elements, are connected with another rod across the trough, to which are suspended the articles to be plated.

Electroplating Bath.—A vessel containing the solution of the metal to be deposited by electroplating.

Electro-pneumatic.—Relating to the action of compressed air in combination with electricity.

Electro-pneumatic Block System.—A railway block system provided with semaphores operated by compressed air under the control of valves having electromagnetic action.

Electro-pneumatic Thermostat.—A device for opening or closing an electric circuit by the expansion of a gas when heated beyond a given point.

Electropoion.—A trade name for the electrolyte employed in the Fuller cell. It consists of three parts bichromate of potash, one part sulphuric acid and nine parts water.

Electro-polar.—Having one end or surface positively electrified and the other negatively electrified.

Electro-positive.—1. Possessing positive electrification.

2. Relating to those elements in electrolysis that appear at the cathode.

Electro-positive Ion.—In electrolysis, the element which appears at the cathode or negative electrode; the *cation.*

Electro-positive Radical.—The electro-positive *ion.*

Electro-positives.—The electro-positive ions.

Electro-potential Energy.—Electrical energy having the capacity of doing work, but not actually at work; electric energy in reserve.

Electro-prognosis.—In electro-therapeutics, a scientific calculation of the probable outcome of the disease based upon the diagnosis of the case by the application of electric currents to the diseased parts.

Electro-psychology.—A proposed name for the study of so-called animal magnetism.

Electro-puncture.—The surgical operation of inserting one or more needles in an affected part of the body and then applying an electric current for the removal of diseased growths.

Electro-pyrometer.—An instrument for measuring high temperature by the increase in the electric resistance of platinum wire exposed to the heat.

Electro-receptive Devices.—Devices of various kinds designed for utilizing the electric current as it passes into or through them; *translating devices.*

Electro-refining.—The refining of metals by means of electricity.

Electroscope.—An instrument used to detect the presence of an electric charge and to determine whether the charge is positive or negative. A familiar form is the gold leaf electroscope consisting of two strips of gold foil suspended from a brass rod within a glass jar. To measure the amount of the charge, however, it is necessary to use an *electrometer*.

Electroscopic Gauge.—A name given to an early variety of gold leaf electroscope.

Electroscopy.—The use of the electroscope in detecting the presence and determining the kind of electric charges.

Electrose.—A trade name for a substance manufactured into high power transmission insulators. It has a brown, smooth polished surface, is very strong, does not absorb moisture, and possesses good insulating properties.

Electro-semaphore.—A semaphore (a railway signal) operated by electricity.

Electro-silvering. — Electroplating with silver.

Electro-smelting.—The reduction of metals from their ores by heat derived from electricity.

Electro-static Attraction.—Attraction exerted upon each other by bodies carrying unlike electric charges.

Electro-static Aurora.—A term sometimes applied to electro-static corona.

Electro-static Capacity.—The quantity of electricity with which a condenser must be charged in order to raise its potential to a given amount, the electrical unit of capacity is the *farad*.

Electro static Charge Current of Cable.—A sudden rush of electricity into a submarine cable as soon as an electromotive force is applied to the line.

Electro-static Circuit.—1. A circuit through which an electro-static discharge passes.

2. A circuit composed of the paths of electro-static flux or lines of force.

Electro-static Corona.—The luminous phenomena which occur on the surface of a thin sheet of mica or similar insulator when inserted between two electrodes which have a high difference of electrical potential.

Electro-static Current.—The rate of flow of electro-static lines of force through an electro-static circuit.

Electro-static Difference of Potential.—Difference of potential occurring in electrified bodies.

Electro-static Discharge.—A *disruptive* discharge. A sudden discharge of static electricity which takes place in the form of a flash or spark across a non-conducting medium, lying between two electrified bodies having different potentials, when the stress upon the medium causes it to give way to the passage of the electricity.

Electro-static Field.—The region occupied by electro-static lines of force in the vicinity of an electro-statically charged body; electro-static field of force.

Electro-static Flux.—The lines of force traversing an electro-static field.

Electro-static Force.—The force between any two electrified bodies which causes them to attract or repel each other.

Electro-static Generator.—An electro-static *induction machine*.

Electro-static Indicator.—A term sometimes applied to the *electrometer*.

Electro-static Induction.—The power which a charged body possesses of causing an opposite electrical state in its vicinity under certain conditions.

Electro-static Induction Machine.—A machine for generating electricity upon the principle of electro-static induction. A small initial charge is made to increase rapidly by the rotation of one or more glass discs. They are made in a variety of forms and are often called *influence machines*.

Electro-static Influence.—A term sometimes applied to *electro-static induction*.

Electro-static Leakage.—The gradual loss of electrification from a charged body which inevitably takes place because of the impossibility of effecting absolute insulation.

Electro-static Lines of Force.—The lines of force traversing an electro-static field; *electro-static flux.*

Electro-static Motor.—A motor driven by electro-static induction acting between two electro-static fields.

Electro-static Optical Stress.—A stress, due to electro-static expansions and contractions, producing a strain upon glass or other optical mediums, which can be observed by the aid of a ray of polarized light.

Electro-static Potential.—The capacity of doing work possessed by a particle of matter charged with one unit of positive electricity.

Electro-static Repulsion.—Repulsion exerted against each other by bodies carrying like electro-static charges.

Electro-static Resistance.—The resistance offered by a charged body to the flow of electro-static lines of force.

Electro-static Retardation.—In telegraphy, retardation in transmission due to capacity of the line.

Electro-statics.—That branch of the science of electricity which treats of the properties of simple electrified bodies or of electricity supposed to be *at rest*, as distinguished from electro-kinetics which deals with electricity *in motion.*

Electro-static Strain.—The strain experienced by a substance exposed to an electro-static field of force.

Electro-static Stress.—A stress of tension and compression producing an electro-static strain upon a body in an electro-static field.

Electro-static System.—The system of electro-static units.

Electro-static Units.—A system of units of measurement based upon the attraction or repulsion between electric charges; the *electro-static system.*

Electro-static Voltmeter.—A voltmeter designed to measure high voltages, based upon the principle of electro-static attraction between two bodies charged to opposite potentials; it acts on the principle of the quadrant electrometer, and consists essentially of a fixed conductor in the form of two insulated butterfly shaped sheets of brass, and a movable conductor consisting of a thin strip of aluminum resting upon a knife edge; an electrometer voltmeter, or *open circuit voltmeter*

Electro-static Wattmeter.—A modification of the quadrant electrometer designed to give readings directly as a wattmeter.

Electro-steeling.—Electroplating the copper plates used in engraving with a thin coating of iron.

Electro-stenolysis.—In electro-chemistry, a phenomenon closely related to electrical endosmose. It has been observed that, when a salt solution separated into two portions by capillaries is electrolyzed, a deposition of metal takes place in the capillaries. This action is called electro-stenolysis.

Electro-stereotype.—A term sometimes applied to the *electrotype.*

Electro-stereotyping.—A term sometimes applied to electrotyping.

Electro-striction.—A phenomenon in electro-chemistry, in which all liquids whose dielectric constant is increased by pressure, suffer a contraction in a strong electric field.

Electro-synthesis.—The process of chemically combining electro-positive and electro-negative elements by means of electricity.

Electro-taxis.—The influence of electricity upon the direction of movement of simple living organisms.

Electro-technics.—The science of the application of electricity to the industrial arts.

Electro-thanasing.—Meeting accidental death from an electric current or shock.

Electro-therapeutic Bath.—A bath provided with electrodes for the application of electricity in the cure of disease.

Electro-therapeutic Breeze.—A brush discharge of electricity from the point of a positively charged conductor employed in electro-therapeutics.

Electro-therapeutic Diffusion.—The spread of electric current in uneven densi-

ties through the different portions of the human body lying between two electro-therapeutic electrodes.

Electro-therapeutic Dosage.—Adjusting the proportion of an electro-therapeutic application to the requirements of the case under treatment.

Electro-therapeutic Electrode.—An electrode suitable for the application of electricity to the body in the treatment of disease.

Electro-therapeutic Galvanization.—The effects produced on the tissues of the human body by the electric currents applied for the cure of disease.

Electro-therapeutic Head Breeze.—A convective electric discharge for treatment of the head in electro-therapeutics.

Electro-therapeutics.—The use of electricity in the treatment of disease; *electropathy.*

Electro-therapeutist.—One who is skilled in medical electricity, or who practices electro-therapeutics.

Electro-therapy.—A term sometimes applied to electro-therapeutics.

Electro-therm.—An electric heating apparatus employed in electro-therapeutics; it consists essentially of an asbestos mat containing a resistance wire woven in, the whole enveloped in a pad of felt.

Electro-thermal Chemistry.—The branch of electro-chemistry embracing the methods in which the electric current increases the temperature of substances so as to produce fusion, chemical action and other effects. Electro-thermal processes include the production of calcium carbide from lime and carbon in the electric furnace; the smelting of metallic compounds by the heat of an electric current, as the reduction of iron ore in an electric furnace; the electric fusion of refractory substances, such as silica and alumina; and the working of various metals by electric heat, as in welding, forging, rolling, casting.

Electro-thermal Meter.—A term sometimes applied to the hot wire ammeter or voltmeter which operates on the principle that if an electric current be passed through a constant resistance, the heat generated must be equal to the square of the current. The Cardew voltmeter is the earliest type of electro-thermal meter.

Electro-thermancy.—That branch of the science of electricity which treats of the thermo-electric effects at a junction in a circuit composed of dissimilar conductors.

Electro-thermic or Electro-thermotic.—Relating to heat generated by electricity.

Electro-tinning.—Electroplating with *tin.*

Electro-tint.—A method of making a design in relief for printing by suitably treating the plate upon which the lines are drawn, and then subjecting it to the action of an electro-bath.

Electro-tinting—The process of preparing an electro-tint.

Electrotisic.—Relating to the electric death penalty.

Electrotising.—Inflicting capital punishment by applying a current of electricity; commonly called *electrocution.*

Electrotome.—A name for a variety of automatic contact breaker which has such a rapid movement as to produce sound.

Electrotonic Effect.—A term sometimes applied to electrotonus.

Electrotonic Excitability.—The excitability of a nerve or muscle by the passage of an electric current through it.

Electrotonic Theory.—A theory of electricity which accounts for light and other radiations as being disturbances set up in the surrounding ether by the change in the motions of the corpuscles or infinitesimal units of electricity which exist in the ether.

Electrotonus.—The altered state of a nerve or muscle resulting from the application of an electric current.

Electrotype Process.—The process of making electrotypes or *electros.*

Electrotyping.—The reproduction of type, wood cuts, etc., in copper, by the aid of electro deposition. A mould is first made of the set type in wax; this mould is next coated with black lead to give it a metallic surface, as the wax is a non-conductor; the mould is then subjected to the process of electro deposition, resulting in the formation of a film of copper on the prepared surface. The copper shell is removed from the

mould by applying hot water: the shell is then backed up with electrotype metal to render it strong enough for use.

Electro-typographic.—Relating to printing with the aid of electricity.

Electrovection.—A phenomenon observed when a strong electric current is passed through certain liquids when a porous partition is placed between the electrodes. The current carries a part of the liquid through the membrane in the direction of the flow of electricity; electric *osmose.*

Electro-vital.—Relating to electricity associated with vitality.

Electro-vitalism.—A system or theory pertaining to the relations between electricity and vitality.

Electrum.—1. A name for *amber,* a substance which may be readily electrified by friction.

2. An alloy of gold and silver made by the ancients.

Element.—In chemistry, one of the simple constituents of matter which, thus far, has resisted all efforts of the analyst to decompose it further.

Elementary Matter.—Matter which cannot be chemically decomposed into simpler forms; *the elements.*

Element of Current.—A small fraction of an electrical current taken for convenience in mathematical processes.

Elements of Primary Cell.—The substances which form the voltaic couple of a primary or *voltaic cell.* The elements consist of (1) the *electrodes* or plates of metal or other substance. One plate made of zinc is called the generating electrode and the other plate the conducting electrode. The latter is usually made of carbon, copper being the next most commonly used, (2) the *electrolyte* or *exciting fluid* which is the liquid in which the electrodes are immersed and which acts upon them and produces a current in a wire connecting the two.

Elements of Storage Battery.—A pair of prepared metal plates suitable for use as the accumulators of electrical energy in a cell of a secondary or *storage battery.*

Elements of Windings.—The conductors which make up the windings of a dynamo or motor armature.

Elevator.—A lift or hoist consisting of a platform or cage, working between vertical guides, operated either through ropes driven by steam, electricity, compressed air, or water power, or by the direct thrust or lift of a hydraulic plunger. An electric elevator is usually provided with a switch and rheostat by which it is started, stopped and reversed. Pulling the rope downwards as far as possible causes the car to ascend. A slight pull in the opposite direction opens the switch, allows the brake to apply and the car comes to a stop. Pulling the rope upwards as far as possible causes the car to descend. The same effect is produced by the turning of a hand wheel—forwards or backwards.

Elevator Annunciator.—An annunciator carried by an elevator for the purpose of indicating to the operator the number of the floor from which a call is sent.

Elevator Switch.—A switch carried by an elevator for controlling the motor which operates the elevator.

Ellipse.—A plane figure enclosed by a curved line, which is such, that the sum of the distances between any point on the circumference and the two foci is invariable. The ellipse may also be defined as a conic section obtained by a plane cutting a cone obliquely to its axis.

Elliptical Arch.—A masonry arch built to a semi-ellipse instead of a semi-circle, to avoid excessive rise in the centre.

Elliptically Rotating Magnetic Field.—A rotating magnetic field in which phases of current vary between zero and 90°, so that the diagrammatic representation is a uniformly rotating line varying in length and tracing an ellipse.

Elongation.—1. The amplitude of the angle described by a measuring instrument which starts at zero and ends at a maximum value. With galvanometers, elongation shows the value of the current passing in the galvanometer.

2. The amount to which a test piece of plate stretches, between two fixed points, due to a steady and slowly applied force, which pulls and separates it. This elongation is made up of two parts: one due to the general stretch, more or less, over the length; the other, due to contraction of area at or about the point of fracture.

Embedded Coils.—Armature coils wound in grooves or channels sunk into the surface of a dynamo or motor armature.

Embosser.—A type of telegraph receiver which registers a message by embossing the

signals upon a paper ribbon; *a telegraphic embosser.*

Emergency Brake.—A brake of exceptional power furnished to electric vehicles for use only in emergencies.

Emergency Cable.—A light cable of convenient length suitable for temporarily mending an overhead line after an accident while repairs are in progress.

Emergency Crew.—A gang of men ready to respond to an emergency call in case of accident in an electric distribution system.

Emergency Switch.—A supplementary switch on the controller of a trolley car for reversing the motor in an emergency.

Emery.—This is a dark colored granular variety of *corundum,* which is the hardest substance found native, next to the diamond. The emery rocks are crushed into powder of varying degrees of fineness, which are used in that state as abrasive or polishing agents, or else consolidated with various binding materials into hones or wheels and discs for grinding purposes.

Emery Paste.—A polishing material composed of grease combined with the finest emery powder.

E. M. F.—Abbreviation for *electromotive force.*

Emission.—The act of emitting, giving or throwing out; as, the emission of light and flame.

Emissivity.—Radiating power, or capacity for emitting radiation.

Emissivity of Filament.—The radiating power of a filament when conducting an electric current.

Empaneled Wires. — Wires concealed within panels or mouldings.

Emptied.—A term applied to a condition of a storage battery or condenser when discharged.

Empyrical.—1. Of or pertaining to combustion.

2. Having a combustible principle; as, coal.

Enamel.—A substance of the nature of glass, but more fusible and more opaque, used for giving a highly polished, ornamental surface; as, enameled metal or enameled brick.

Enameling.—In engineering, the process of covering the surface of metals with nonmetallic coatings similar to varnish. Two principal kinds are employed, viz., vitrified enameling, which consists in covering the surface of cast iron, or other metal, with a coat of vitrifiable material similar to glass; and varnish enameling consisting in covering the metal with some form of varnish at moderate temperature. The latter process is employed for the chassis of motor cars.

Enclosed Arc Lamp.—A form of arc lamp in which a small globe encloses the arc so that only a small amount of air is permitted to enter, thereby retarding the consumption of the carbons and increasing the life of the lamp far beyond that of the original simple open arc type.

Enclosed Fuse.—In a system of electric wiring, a safety fuse placed within a tube of vulcanized fiber, paper or similar material containing contacts at the ends, and filled with some light porous material When an enclosed fuse is blown, the formation of an arc is prevented either mechanically or by the chemical action which takes place between the filling and the melted fuse. This type of fuse is commonly called from its shape and sise a *cartridge fuse.*

End Cells.—The cells near the end of a storage battery which are cut in and out of circuit by means of the end cell switches in order to keep the voltage constant at the battery terminals.

End Cell Switch.—A form of switch employed in connection with a storage battery in order to control the end cells for regulating the voltage; *battery switch.*

End Connectors.—Copper plates used for connecting up the ends of the conducting strips of a bar armature; *end windings.*

Endless Belt.—A belt which returns upon itself so as to have neither beginning nor end, passing over two or more pulleys to transmit power.

Endless Chain.—A chain whose ends have been united by a link.

Endoscope.—A lamp suitable for illuminating internal cavities of the human body for purposes of medical examination.

Endosmometer.—An instrument for measuring the action of endosmose.

Endosmose.—The passage of a fluid through a porous partition into another denser fluid, and the consequent mixing of the two.

Endosmose, Electric.—The passage of an electrolyzed liquid into another denser liquid through an interposed septum or partition.

Endosmotic Equivalent.—The ratio between the amount of water that passes through a porous medium to the amount in exchange of a substance in solution.

Endothermic.—Relating to absorption of heat.

Endothermic Compound.—In chemistry, a compound which is formed from its elements with absorption of heat.

Endothermic Reaction.—A chemical reaction accompanied by absorption of heat.

End Play.—Movement endwise, or room for such play or movement.

End to End Joint.—A method of joining two lengths of wire by bringing the ends into close contact and soldering or welding them together; commonly called the "*butt-joint.*"

Endurance.—The capacity of a material to resist stresses, especially those known as live loads, where rapid alternations of forces take place.

Energetics.—That branch of science which treats of the laws governing the physical or mechanical, in distinction from the vital forces, and which comprehends the consideration and general investigation of the whole range of physical phenomena.

Energy Component.—In an alternating current circuit, the working or active component of the current in phase with the volts, as distinguished from the *wattless* component which differs in phase from the volts by 90° and contributes nothing to the watts.

Energy Current.—In an alternating current circuit, the working or active component of the current in phase with the volts; the *energy component*, as distinguished from the *wattless component.*

Energy Efficiency.—The efficiency of an electric machine measured in watt hours or kilowatt hours; the *watt hour efficiency.*

Energy, Electric.—The work done in a circuit or conductor by a current passing through it. When a current flows from one point to another, electric potential energy is lost and work is accomplished. The amount of this work is measured by the quantity of electricity that flows, multiplied by the difference of potential under which it flows; its unit is the *joule.*

Energy Meter.—A name sometimes given to the *wattmeter.*

Energy of Motion.—The energy possessed by a body in virtue of its motion; *kinetic energy;* it is the work necessary to bring a body from its actual velocity to a state of rest. The measure of the kinetic energy is the product of the weight of the body, multiplied by the height from which it must fall to acquire its actual velocity.

Energy of Position.—Potential energy, or the energy possessed by a body in virtue of its position, as distinguished from the energy of motion or *kinetic energy:* water stored in an elevated reservoir represents potential energy, since its liberation to a lower level may be utilized to effect work, as in a *hydro-electric power plant.*

Energy of Rotation.—The product of the moment of inertia in a rotating body by one-half of the square of its angular velocity.

Energy Storage Capacity.—The amount of electrical energy in the form of chemical work, measured in watt hours, that a secondary cell is capable of accumulating.

Energy Transforming Device.—Any apparatus for changing one form of energy into another.

Engage.—To interlock with another part; as, the teeth of geared wheels with each other, or a rack with its pinion.

Engaged Test.—In a multiple telephone switchboard, the so-called "*busy test*" employed by the operator to prevent making connection with a line which is already in use at another board. The test is made by applying the tip of the calling plug of the test pair to the thimble of the jack of the subscriber wanted. If the line is in use, a click will sound in the operator's telephone.

Engine.—A compound machine or mechanical contrivance by which any physical power is applied to produce a given effect.

The term engine is more commonly applied to massive machines, or to those of great power, or which produce some difficult result. It takes, in composition, other words, designating either the source of power, as steam engine, air engine, caloric engine, or the purpose to which it is applied: as, fire engine, pumping engine, locomotive engine; or some peculiarity of construction, operation, or use: as, single acting or double acting engine, high pressure or low pressure engine.

Engine Counter.—A device which records by wheel combinations the revolutions of an engine or machine where it is necessary or convenient to know the number of rotary turns within a specified time. Whatever number of dials or wheels there may be, the right hand figure represents the units, the second figure the tens, etc. This ingenious mechanism is capable of various applications relating not only to the number of revolutions the engine has made, but telling how many miles a steamer has gone.

Engineer, Electrical.—A person versed in the science of electricity, and skilled in electric practice; usually one who has had special training in an engineering school and obtained the degree E. E.

Engine Telegraph.—A telegraph system installed upon a steamship for sending signals to the engine room.

English Heat Unit.—The amount of heat required to raise the temperature of one pound of water one degree F.; the *British thermal unit.*

Engraving, Electric.—A method of etching metal plates by the action of electrolysis. It consists of covering a metallic plate with wax and tracing thereon the design, so as to expose the metal. The positive terminal of a battery or dynamo is then connected with the metal which is then placed in a bath opposite another plate of metal connected with the other terminal of the battery. The action of electrolysis dissolves the metal on the exposed portions of the waxed plate and deposits it on the other plate.

Entrefer.—The open space between the face of the pole piece of a dynamo and the surface of the armature; *the air gap.*

Entropy.—In thermodynamics, a certain property of a body, expressed as a measurable quantity, which remains constant if no heat enters or leaves the body while it does work or alters its volume, but which increases or diminishes should a small amount of heat enter or leave.

Environment.—The conditions, forces or objects with which anything is surrounded.

Eolotropic or Æolotropic.—A term applied to a substance which has different properties in different directions through its mass.

Epinus' Condenser.—A form of electrostatic machine devised by Epinus (Æpinus) in which the brass discs are separated only by a stratum of air between them, the air being sufficient to insulate the two charges from each other, thus forming an *air condenser.*

Epoch.—1. A period of time considered as a unit with reference to the occurrence of natural phenomena.

2. In simple harmonic motion the time required by a moving point to reach greatest positive elongation.

Equal Arms Balance.—A Wheatstone's bridge in which the resistances of the arms are equal.

Equality.—The state of exact similarity between two or more bodies; the possession of identical weight, bulk, and dimensions.

Equalize.—To make equal; to cause to correspond or be like in amount or degree, as compared.

Equalizer.—1. An equalizing bar or wire.

2. A device for producing a uniform pressure of electricity throughout a system.

3. A low resistance connection between the armature ends of the field coils, used when series dynamos are run in parallel.

Equalizer Connection.—When two or more compound wound generators are operating parallel, a connection is established between their series coils by a heavy bus bar known as an equalizer bar or bus, so as to prevent the currents in the series fields from differing widely from each other, however their armature currents may differ. If the difference be small, it may be compensated by means of the hand regulator; if large, however, other means must be taken to cause the machines to take up their due proportion of the load. If the series coils of the several dynamos are provided with small adjustable resistances, in the form of German silver or copper ribbon inserted in series with the coils, the distribution of the current in the latter may be altered by varying the resistance attached to the individual coils, and thus the effect of the series coils upon the individual armatures in raising the pressure may be adjusted, and the load thus evenly divided among the machines.

Equalizer Rings.—Rings resembling a series of hoops provided in a parallel wound armature to eliminate the effects of "unbalancing" by which the current divides

unequally among the several paths through the armature. By means of leads, these rings connect points of equal potential in the winding, and so preserve an equalization of current.

Equalizer Wire.—In the case of two compound dynamos working in parallel, a wire joining the series coils of each machine so that equal potential shall be maintained at the points of junction.

Equalizing Bar.—A bar for maintaining equal potential, joining the series coils of two compound dynamos working in parallel.

Equalizing Current.—When compound wound dynamos are operated in parallel, the current carried by the equalizer bar to insure uniform distribution among the series coils of the machines.

Equalizing Dynamo.—In storage battery practice, an extra dynamo, usually called the "*booster,*" connected into the circuit of the battery for regulating the charge, and sometimes the discharge of the battery.

Equalizing Resistances. — Resistance coils sometimes employed with a system of feeders to reduce the pressure in the shorter feeders, when the bus bars are maintained at the pressure required by the longest feeders.

Equator.—1. A great circle surrounding any sphere midway between its poles; or that circle which passes around any spheroid of revolution in a plane through its centre and at right angles to its axis.

2. The great circle about the earth's circumference at every point equidistant from the north and south poles, which divides the northern from the southern hemisphere.

Equatorial Region of Magnet.—The neutral portions of a magnet at its equator.

Equator of Magnet.—A line assumed to encircle a magnet at a point where there is no polarity or attractive power; a line passing through the *neutral* points. In a bar magnet it lies midway between the poles.

Equidistant.—Situated at equal distances from the same point or thing.

Equilibrium.—The state of a body in which all the forces acting on it balance one another; the condition of absolute poise.

Equilibrium of Forces.—In mechanics, a counterpoise or state of rest produced by the mutual counteraction of two or more forces.

Equilibrium of Radiation.—The state of a radiating body which absorbs an amount of radiant energy equivalent to that which it emits.

Equimolecular Solution.—A solution in which the dissolved substance is present in proportion to its molecular weight.

Equipment.—The collective designation for the articles comprising an outfit.

Equipoise.—Equality of weight or force; a state in which the two ends or sides of a thing are balanced.

Equipotential.—Equal with respect to potential.

Equipotential Electro-static Surface.—The locus of all points in an electro-static field at which the potential has the same given value.

Equipotential Magnetic Surface.—The locus of all points in a magnetic field at which the potential has the same given value.

Equipotential Winding.—In armature winding, a method of overcoming the difficulty arising in lap windings due to the interchange of current among the various paths of the coils when the pressures are not equal in them. A number of equipotential points in the winding are bonded together, the rings for this purpose being located at the end of the core, opposite the commutator.

Equivalent.—That which is equal in value, weight or force.

Equivalent Resistance.—A resistance equal to the sum of other resistances in an electric current.

Equivalent Sine Wave.—One having the same frequency and the same root of mean square value as the actual wave.

Equivalent Sinusoids.—Sinusoidal curves taken for purposes of investigation to represent irregular alternating current waves, as giving an equivalent effect and representing *equal power.*

Equivolt.—A term proposed for the mechanical energy of one volt electromotive

force exerted under unit conditions through one equivalent of chemical action in grains.

Erb's Standard Electrodes.—Standard sizes of electro-therapeutic electrodes.

Erection.—In civil and mechanical engineering, the act of erecting or raising upright; the act of constructing; as, a building or a wall, or of fitting together the parts of a machine or a steel frame structure.

Erector.—A skilled mechanic employed in assembling together the various parts of a machine. Most usually, an artificer who builds or erects steam-engines, from wholly or partially completed details, in the factory, or who subsequently installs them in the place of their ultimate employment.

Erg.—The unit of *work* in the C. G. S. system; it is the work done when a force of one dyne acts through a distance of one centimeter.

Erg Meter.—An instrument for measuring in ergs the energy of an electric current.

Ergometer.—An *erg meter.*

Erg: s.—An abbreviation for *erg per second.*

Erg Ten.—A unit of work employed in large measurements when a small unit like the erg would be inconvenient; it is equal to 10 *ergs* or 1000 *joules.*

Error.—A blunder of any kind in transmitting or receiving a telegraphic message.

Escape, Electric.—1. The escape of an electric current through faulty insulation.
2. The gradual dissipation of the charge from an electrified surface.

Escapement, Electric.—A clock escapement controlled by electricity.

Escape Pipe.—A pipe for carrying away steam; as, that which escapes from a safety valve.

Estimate.—A valuing or rating without actually measuring, weighing or the like; to compute; to calculate; to reckon.

Etching, Electric.—A process of etching a metal plate by subjecting the portions that are not coated with a non-conducting material to the action of electrolysis. Wax is used as the coating, upon which the design is traced, leaving portions of the metal exposed. The plate is put in a bath and connected to the positive terminal of an electric source, the negative terminal being placed in the bath: metal is dissolved from the plate by electrolysis; leaving an imprint of the design upon the plate.

Ether.—A medium of extreme lightness and elasticity that is assumed to pervade all space and to be diffused even within solid bodies. It is the basis of the explanations of many physical phenomena and theories.

Ether Streamings.—Streamings that are supposed to be set up in the ether about the poles of a magnet.

Ether Theory.—A theory of electricity which identifies it with the luminiferous ether, based upon the discovery of Maxwell that light itself is a manifestation of electricity, being motion of the ether in electromagnetic waves.

Eudiometer.—A graduated glass tube, used in the analysis of gases, for measuring their volume.

Evaporation.—The act of changing into vapor which takes place at the surface of a liquid.

Evaporation, Electric.—The evaporation of a liquid and volatilization of a solid, accelerated by the influence of negative electricity.

Evaporative Efficiency.—The measure of the efficiency of a boiler in evaporating water as compared with the theoretical value of a certain amount of fuel. Commonly expressed as so many pounds of water at 212° F., evaporated into steam at the same temperature, the unit of fuel consumed being one pound of dry coal.

Ewing's Theory of Magnetism.—A theory of magnetism advanced by Ewing, that molecular magnets are held together, not by friction but by mutual magnetic attraction, their poles pointing in every direction till some outside magnetic force draws them into a common direction.

Excitability, Electric.—The stimulus to a nerve or muscle occasioned by the application of an electric current.

Excitant.—The electric energy which excites activity in an electro-receptive device.

Excitation.—1. The electrification of a substance.

2. The magnetization of a magnetizable substance.

3. The magnetizing of the field magnets of a dynamo or motor by the passage of a current through the winding of the magnets. The exciting current is obtained either from the machine itself in self-exciting dynamos, or from an outside source in separately excited dynamos.

4. In electro-therapeutics, the stimulation of muscular or nerve tissue in the human body.

Exciter.—In wireless telegraphy, a name given to that portion of the oscillator or transmitting apparatus at which the sparks are produced that set up the electric waves which are radiated into space; the *exploder*.

Exciter Dynamo.—A dynamo employed in separately exciting the field magnet of another dynamo; an *exciter*.

Exciting Ampere Turns.—Ampere turns in the coils of a dynamo or motor field magnet by which the electromagnetic field is produced.

Exciting Current.—The current applied to the windings of the field magnets of a dynamo or motor in order to produce magnetization.

Exciting Fluid of Voltaic Cell.—The solution which forms the electrolyte of a voltaic cell.

Execution, Electric.—Capital punishment by the use of electricity; *electrocution*.

Exhaust.—1. To empty of anything; to deplete.

2. The passing of steam or other working fluid from a cylinder to the atmosphere or the receiver of the next successive cylinder, after it has pushed the piston to the end of its journey in one direction.

Exhausted Primary Cell.—A primary cell which has lost its power to generate a current.

Exhausted Storage Cell.—A storage cell which has been discharged or emptied.

Exhaust Fan.—An air propeller used to create a vacuum; the opposite to blowing fan.

Exhaust Fan, Electric.—An exhaust fan operated by electricity.

Exhaust Head.—An apparatus placed upon the top of a steam exhaust pipe to prevent the condensed steam from being blown about.

Exhaustion, Electric.—An effect of physical exhaustion sometimes suffered by persons long exposed to powerful arc lights.

Exhaustion of Primary Cell.—The condition of a primary cell which has lost its power to generate a current until electrolytes or electrodes are renewed.

Exhaustion of Storage Cell.—The condition of an empty secondary cell which renders it useless until recharged.

Exhaust Lap.—Also known as *inside lap*; extension of the exhaust edges of a slide valve in a steam engine to promote cushioning by closing the exhaust early.

Exhaust Line.—A steam indicator term; counter pressure or back pressure line in a diagram, showing the steam pressure between the commencement of pre-release and the beginning of compression.

Exosmose.—The passage of liquids through membranes in a reverse direction from that of *endosmose*, that is, of a denser liquid into one less dense.

Exothermic Compound.—In chemistry, a compound which is formed from its elements with the giving out of heat.

Exothermic Reaction.—A chemical reaction accompanied by the liberation of heat.

Expanded Metal.—A material used in reinforcing concrete for walls, partitions, conduits, etc. Thin sheets of mild steel are placed upon edge and with one operation the metal is slotted and drawn out into a sort of network, the arris of each opening being turned practically at right angles to the original plane.

Expanding Magnetic Field.—A magnetic field in which the lines of magnetic force are increasing in strength and extending in area.

Expansion.—1. The act or process of increasing in bulk; dilatation of any substance through its particles becoming more widely separated from one another by the

influence of heat. With gases, the property of expansion is characteristic, that is, any gas admitted into a closed chamber will immediately dilate until it has completely filled the chamber, sometimes becoming extremely rarefied in the process. With open ports the expansive energy of steam acts from the water in the boiler as its fixed point of fulcrum, but after it is "cut off" it acts from the fixed ends of the cylinder.

2. That portion of the cycle of a heat engine in which the fluid gives off the initial energy stored in it, while being gradually expanded down to the point at which it is rejected from the engine.

Expansion, Electric.—The increase in bulk which occurs in a body upon receipt of an electric charge. It has been observed that a Leyden jar curiously increases in volume as it receives a charge, the electricity producing the effect of expanding the glass.

Expansion Line.—The curve traced by the pencil of a steam engine indicator corresponding with the gradual fall of pressure in the cylinder during expansion; the line approximates to the curve known as the *hyperbola.*

Expansion of Steam.—1. That repellent force imparted to water by heat which causes each particle to repel and drive to the greatest possible distance every other particle of the mass.

2. That portion of the stroke of a steam engine in which the steam supply is cut off by the valves, and continues to perform work upon the piston, accompanied by increase in volume and consequent decrease in pressure. By this means, a greater proportion of the energy stored in the fluid is recovered as useful effort.

Expended Energy.—The energy which has been put forth to do work.

Experiment.—A practical test. A trial deliberately instituted; an act or operation undertaken in order to discover something unknown, or in order to test, establish, or illustrate some allied or known truth.

Expert.—One who has skill, experience, or peculiar knowledge on certain subjects of inquiry in science, art, trade, or the like.

Exploder.—A small magneto generator for the purpose of furnishing current in the electric exploding of blasts.

Exploration of Magnetic Field.—The use of an exploring needle in determining the characteristics of a magnetic field.

Explorer, Electric.—An instrument acting on the principle of induction, designed to indicate the location of foreign metallic matter within the human body.

Exploring Needle.—1. An electric probe for surgical use.

2. A magnetic needle for investigating an electromagnetic field.

Explosion.—A bursting with violence and loud noise, due to a chemical action which causes the sudden formation of a great volume of expanded gas.

Explosive.—A chemical substance, solid or liquid, one of the constituents of which is instantaneously converted into gas on ignition or detonation, exerting enormous pressure.

Explosive Distance.—In an induction or spark coil, the distance that the spark will jump through the air between the terminals; the sparking distance.

Explosive Engine.—In machinery, an engine the piston of which, in the cylinder, is moved by a chemical action which causes the sudden formation of a great volume of expanded gases; as, in a gas engine. Usually called *internal combustion engine* or *gas engine.*

Explosive Mixture.—1. A finely subdivided substance suspended in the atmosphere, which deflagrates and undergoes chemical change with intense rapidity, accompanied by great heat and the evolution of gaseous products occupying a much greater volume than the original mixture. Coal dust in a mine and the fine floury dust in a mill give occasional instances of the tremendous energy latent in such mixtures.

2. Under control, fine sprays of liquid hydrocarbons, or solutions of gaseous ones in ordinary air, furnish, by explosion, the energy to drive gasoline or gas engines.

Extension Call Bell.—1. A call bell situated at some point remote from the apparatus or instrument to which it belongs, so placed that it may summon a person from another part of the building.

2. A call bell provided with a relay which causes it to ring indefinitely after the main current is cut off.

Extension Push Button.—An extra push button situated at some point remote from the principal push button.

Extensometer.—An apparatus for measuring the expansion or contraction of metal bars affected by the temperature or by strain.

External Characteristic.—The characteristic curve in which is plotted the potential difference at the terminals of a dynamo, corresponding to various values of the current.

External Circuit.—The portion of an electric circuit which is outside of the generator.

External Forces.—In mechanics, forces which act upon bodies from without and are therefore the forces which produce strain.

External Magnetic Circuit.—That portion of a magnetic circuit which exists outside of the substance of the magnet itself.

External Magnetic Field.—That portion of a magnetic field which exists outside of the substance of the magnet itself.

External Resistance.—The resistance existing in an electric circuit outside of the dynamo or battery; *non-essential resistance.*

Extra Best Best Iron Wire.—The highest grade of iron wire for electrical purposes, being superior in conductivity and uniformity to the other two grades, known as *best best* and *best.*

Extra Currents.—Currents of brief duration caused by electromagnetic induction, arising when a circuit is suddenly opened or closed; self-induced currents.

Extra High Potential.—Pressure in an electric system exceeding 3000 volts.

Extra High Potential Wires.—Conductors designed to convey electric currents of extra high voltage.

Extra Polar Region.—In electro-therapeutics, the area of the body remote from the electrodes.

F.—An abbreviation for Fahrenheit, a thermometric scale.

f.—1. An abbreviation for *farad*, the practical unit of electrical *capacity*.
2. An abbreviation for *force*.

F.—The symbol for the *gilbert*, the unit of magneto-motive force.

Face.—1. The principal surface of a solid.
2. That portion of the curved outline of a tooth in a cog wheel, which lies beyond the pitch circle.
3. The working surface of a slide valve, that is, the surface of a valve which comes into contact with its seat.
4. The dial of a registering instrument of any description.

Facsimile Telegraphy.—An automatic system of telegraphy for transmitting a precise copy of handwriting, or of a picture or diagram; *pantelegraphy*.

Factor.—One of two or more elements of quantities, which, when multiplied together, produce a given result.

Factor of Horse Power.—The horse power developed in an engine of given piston area and rate of piston speed, multiplied by one pound mean effective pressure per square inch.

Factor of Safety.—1. A term expressive of a determined limit to which materials or machines shall be subjected, the safety limit.
2. In wiring, the ratio between the breaking stress of a wire and the maximum tension to which it is subjected in overhead suspension.

Fahrenheit Thermometric Scale.—The thermometer scale in general use in the United States and England. On this scale 32° represents the melting point of ice and 212° the boiling point of water. It is commonly abbreviated Fahr. or F.

Failure to Excite.—A dynamo may refuse to excite its field magnets through some portion of its windings or connections being short circuited, for the reason that the field magnets are deprived of the necessary current. In shunt and compound dynamos there is a certain critical speed below which they will not excite. If the normal speed of the machine is known, it can at once be seen whether the failure to excite arises from this cause, by measuring the speed of the armature with a speed indicator. Insufficient residual magnetism is a fault, although not of frequent occurrence, and it is almost impossible for it to take place if the field magnets are of cast iron. It always occurs when the dynamo is a new one, or when the field magnets have been taken apart for repairs, etc. It may be remedied by passing the current from a few storage cells, or another dynamo, for some time in the proper direction through the field coils Reversed magnetism in fields is a fault of infrequent occurrence. It may be caused by the proximity of other dynamos, but is generally due to reversed connections of the field coils. Under such conditions the field coils tend to produce a polarity opposed to the magnetisation to which they owe their current, and, therefore, the machine will refuse to excite until the field connections are reversed, or a current is sent from another dynamo or a battery through the field coils in a direction to produce the correct polarity in the pole pieces.

Fall and Tackle.—A combination of pulleys arranged in one case to form a block, (hence, "block and tackle"), to secure a multiplication of power. The upper or fixed block gives the mechanical advantage of application, and the lower or movable block, by multiplying the travel of the rope as compared with that of the weight, increases the power in proportionate ratio. Each movable pulley halving the power necessary, with two sheaves the force necessary is one-half of one-half, or one-quarter. Briefly, the weight capable of being lifted is equal to the force multiplied by twice the number of sheaves in the lower block, or by the number of "runs" of rope around them, which is the same thing; the friction of the tackle having to be deducted.

Falling Weight Test.—In structural iron, a test to which rails and bars are subjected, the loads being produced by the falling of weights.

Fall of Pressure.—A drop or decrease of electrical pressure in a circuit due to resistance in the conductor. In a wire of uniform resistance the fall of pressure follows the rule, *that the electrical pressure along a conductor through which a given current flows, falls directly, as the resistance increases, that is, the voltage is inversely proportional to the resistance.* Also called *fall of potential*.

False Face.—A clamp or jaw of lead, brass or soft white metal, made to fit on a vise to protect polished work from marking, also known as *vise clamp.*

False Magnetic Poles.—Points on the earth's surface which resemble magnetic poles, in distinction from the two true magnetic poles.

False Resistance.—A resistance in a circuit due to counter electromotive force; a spurious resistance as distinguished from a true or ohmic resistance.

False Water.—In engineering, when steam is generated rapidly in a boiler, the immediate effect is a rapid rising of the water level in the gauge cocks, due to the increase in volume caused by *admixture of steam.* This sudden increase is termed false water.

False Work.—Timbering or scaffolding; a temporary structure used to protect and assist the construction of a permanent one; as, the false work of a bridge in course of erection.

False Zero.—A zero on a galvanometer scale considered to be at the value of the deflection obtained before the action of forces impressed in the measurement.

Fan.—A rotary wheel like arrangement of vanes and hub combined with a suitable casing or conduit, moving volumes of air for purposes of ventilation, furnace draught, etc.

Fang Bolt.—In building, a bolt in which the nut is a triangular plate with teeth for biting into the timber, the bolt being tightened by revolving the head and shank. They are used for attaching iron work to timber.

Fan Guard.—A wire protection built about an electric fan to secure safety from contact with the revolving blades.

Fan Motor.—An electric motor for rotating a fan.

Fan Shaped Antenna.—In wireless telegraphy, an outspread arrangement of the aerial wires at a long distance station for the purpose of offering greater exposure to electric impulses, and obtaining more distinct impression of them.

Farad.—The practical unit of electrical *capacity;* it is the capacity of a condenser that would be charged to a potential difference of one volt by a charge of one coulomb of electricity. The term farad is a contraction of *Faraday,* the name of the distinguished English scientist.

Faraday Effect.—A discovery made by Faraday that a wave of light polarized in a certain plane can be turned about by the influence of a magnet so that the vibrations occur in a different plane.

Faraday, Michael.—Born 1791, died 1867. An English scientist, famous for his discoveries in chemistry, electricity and magnetism. He first produced the rotation of the magnetic needle around the electric current (1821) based upon Oersted's discovery of electromagnetism in 1820; he discovered electromagnetic induction (1831), a principle upon which is founded the development of dynamo machinery; specific inductive capacity (1838); magnetic polarization of light (1845); diamagnetism (1846). He was a brilliant experimenter, and contributed greatly to the knowledge upon which is based present day practice of electricity.

Faraday's Cube.—An experiment made by Faraday to prove that there is no field of electrical force inside a hollow charged conductor. He built a hollow cube 12 feet each way, covered it with tin foil and gave the whole a high charge of electricity. No electrical field could be detected inside even by delicate electro-static instruments.

Faraday's Dark Space.—A dark space which is observed when a negative charge is being discharged from a pointed conductor. This space separates the glow from the surface of the conductor, the electricity traversing it without becoming luminous.

Faraday's Disc.—A copper disc rotated between the poles of a magnet, having wires with sliding contacts to conduct the current away from the disc. It first illustrated the induction principle, now essentially applied in dynamos.

Faraday's Laws.—Laws of electrolysis or electro-chemical change named from Faraday, their discoverer. They may be expressed as follows:

(a) *The magnitude of the chemical and of the magnetic effects produced in a circuit by an electric current is proportional to the quantity of electricity which passes through the circuit.*

(b) *The quantities of the different substances which separate at the electrodes throughout the circuit are directly proportional to their equivalent*

weights, and are independent of the concentration and the temperature of the solutions, the size of the electrodes and all other circumstances.

Faraday's Net.—A device to show that electrical charges are confined to the outer surface of conductors; it consists of a conical gauze bag fastened to a brass ring on an insulated support and capable of being drawn inside out by a silk thread.

Faraday's Principle.—All dynamos, of whatever form, are based upon the discovery made by Faraday in 1831, that electric currents are generated in conductors by moving them in a magnetic field. Faraday's principle may be enunciated as follows: "When a conductor is moved in a field of magnetic force in any way so as to cut the lines of force, there is an electromotive force produced in the conductor, in a direction at right angles to the direction of the motion, and at right angles also to the direction of the lines of force, and to the right of the lines of force, as viewed from the point from which the motion originates."

In other words, Faraday's principle may be thus stated: If a wire be moved near a magnet across a space in which there are magnet lines, the motion of the wire, as it cuts across those magnetic lines, sets up magnetic whirls round the moving wire, that is, generates a so called current of electricity in that wire.

It is, however, necessary that the moving conductor should, in its motion, so cut the magnetic lines as to alter the number of lines of force that pass through the circuit of which the moving conductor forms part. If a conducting circuit, a wire ring or single coil, for example, be moved along in a uniform magnetic field, so that only the same lines of force pass through it, no current will be generated.

Faradic.—Relating to induced electric currents as obtained from various machines.

Faradic Adapter.—In electro-therapeutics, a device, including an induction coil, for adapting the current of an ordinary incandescent lamp circuit to medical uses.

Faradic Battery.—A variety of induction coil employed in the medical application of electricity; a faradic machine.

Faradic Brush.—An electrode resembling a brush employed in electro-therapeutics.

Faradic Coil.—A medical induction coil, sometimes called the faradic battery; the faradic machine.

Faradic Current.—An intense alternating current produced by a faradic machine for medical purposes.

Faradic Excitation.—Excitation of the tissues of the body by the application of faradic currents.

Faradic Irritability.—Irritation of the tissues of the body following the application of faradic currents.

Faradic Machine.—A variety of induction coil for the medical application of electricity. It consists of a primary coil surrounded by a secondary in which brief but intense alternating currents are produced.

Faradization.—The stimulation and other effects produced upon the bodily tissues by faradic currents; *faradism.*

Faradometer.—In electro-therapeutics, an instrument for measuring the strength of faradic currents.

Fast and Loose Pulleys.—In mechanics, the device installed for supplying belt power to machines. Two uniform pulleys are placed side by side upon the same countershaft, one keyed fast to it, the other revolving freely between stop collars. By sliding the belt sidewise from one pulley to the other, it either revolves idly or else drives the countershaft.

Fastening.—Anything used to secure or make fast; that by which one part is attached to another. Either permanently, as a nail or rivet, or so that it may be released at will; as, a bolt or latch.

Fast Repeater.—In telegraphy, a repeater for high speed signaling.

Fathom.—A measure of length equal to six feet, used chiefly in taking soundings, measuring cordage, etc.

Fatigued.—A term applied to material, as iron, when it has lost in some degree its power of resistance to fracture, due to the repeated application of forces, more particularly when the forces or strains have varied greatly in amount.

Fault.—Any impediment in the working of an electric circuit.

Fault in Casting.—The chief defects in castings are *blow holes*, *cold shuts*, *scabs*, or places where the metal has not filled the whole of the space in the mould, this being due to insufficient iron, too low a temperature at pouring, or portions of sand becoming detached from the mould and blocking the passage. Insufficient venting of the mould will produce the same effects.

Fault Indicator.—A device for testing a line for grounds, crosses, breaks or defective insulation. It consists usually of a magneto generator and bell mounted in a portable box; *a magneto testing set.*

Fault Resistance.—A resistance in an electric circuit due to the existence of a fault.

Fault Searcher.—In submarine cable repairing operations, an instrument for indicating the instant that the point at which the fault is located passes aboard ship as the cable is raised.

Feather.—A key with parallel sides sunk into a recess on a shaft or spindle. The keyway of the boss which fits upon the shaft is made a sliding fit upon the feather, so that if necessary, the boss or hub, while always being driven by the shaft, may be moved lengthwise, as desired.

Feed.—1. To furnish with a current of electricity.

2. To cause the carbons of an arc lamp to preserve a uniform distance from each other in spite of wearing away under the action of the arc.

Feed Check.—The non-return or check valve through which feed water enters a steam boiler.

Feeder.—A supplementary conductor running direct from the generating station and connected to the main conductor at some point where there is danger of a fall of pressure.

Feeder Ammeter.—An ammeter employed in a feeder circuit.

Feeder and Main Distribution.—A system of electric distribution, in which, in order to prevent a fall of potential at remote ends of the line, a series of feeders running direct from the station furnishes additional current to the main conductor.

Feeder Block.—A block supplied with a feeder cut out.

Feeder Box.—In a conduit system, a distributing box for admitting a feeder to its connections.

Feeder Clamp.—A form of clamp for readily connecting a feeder to a main conductor; a feeder clip.

Feeder Clip.—A clamp for connecting a feeder wire to a trolley wire in a street railway system.

Feeder Equalizer.—A resistance or choking coil in the circuit of a feeder to equalize its pressure with that of the other feeders in the system; *feeder regulator.*

Feeder Equalizer Switch.—A switch governing the resistances in a feeder system; an equalizer switch.

Feeder for Trolley Wire.—An independent conductor running direct from the station to some remote point of the trolley wire in order to maintain the pressure at that point.

Feeder Panel.—The panel of a central station switchboard upon which are mounted the appliances belonging to the feeder wires.

Feeder Potential.—The pressure applied to a circuit through a feeder.

Feeder Regulator.—A resistance in the circuit of a feeder to maintain its pressure equal to that of the other feeders in the system.

Feeder Switch.—A switch for cutting a feeder in or out of a distributing circuit.

Feeder System.—In a system of electrical distribution, a method of preventing a fall of potential in long lines by running a number of supplementary conductors from the central station, and connecting them to the main conductor at various points along the line.

Feeder Tubes.—Tubes for running feeder wires underground.

Feeding Center.—A center of electric distribution maintained by a feeder.

Feeding Mechanism.—A mechanism for feeding forward the carbons of an arc lamp to prevent the length of the arc from becoming too great as the carbons wear away.

Feed Line.—A feeding wire or feeder for maintaining the pressure constant at a point in a circuit remote from the generating station.

Feed Water.—The water supplied to a boiler to replace that evaporated; as,

steam or blown off. *Net feed water* is the quantity of water necessary to supply a stated evaporation in a given interval of time; *gross feed water* is the net feed water plus the quantity necessary to provide for that blown out.

Feed Water Heater.—An apparatus for raising the temperature of boiler feed water, either by means of steam heated coils or by direct contact with a jet or spray of steam; exhaust steam being used in either manner. In addition to the fuel economy effected by hot feed, a preliminary heating frees hard water of much of its contained salts.

Feed Wire Insulator.—In an electric circuit, an insulator designed to support a feeder.

Feeler.—A shop tool for gauging or "feeling," the accuracy of workmanship between two abutting surfaces. Thin strips of hardened steel of known thickness are employed, and by mounting several different sizes in a handle, like blades in a pocket knife, a great range of tests can be made by combining the blades.

Fender.—In electric traction, an appliance suspended in front of a trolley car close to the rails for the purpose of removing obstructions from the track, and of guarding pedestrians from the danger of being run over.

Ferranti Cable.—A type of electrical conductor designed to carry high tension currents, consisting of concentric tubes of copper separated by an insulation of paper saturated with black mineral wax.

Ferranti Effect.—A phenomena of the increase of potential difference between mains in an alternating current system observed as the distance increases from the generating station.

Ferric.—A term signifying of or akin to iron; containing or extracted from iron.

Ferric Circuit.—A circuit completely made up of iron.

Ferric Inductance Coil.—An inductance coil having a core of iron.

Ferric Magnetic Circuit.—A magnetic circuit made up entirely of iron.

Ferro Concrete.—Armored concrete; cement concrete reinforced by steel rods and bars suitably disposed to receive the tensile stresses, while the compression stresses are met by the concrete itself, which while weak in tension, possesses great strength to resist crushing.

Ferro-magnet.—A term sometimes applied to a substance which, like iron, is attracted to a magnet; a substance having paramagnetic properties.

Ferro-magnetism.—The magnetic property possessed by substances such as iron, nickel, cobalt, manganese and chromium of being attracted by a magnet so that they tend to lie in the direction of the magnetic lines of force. This property is usually known as simply magnetism or better, *paramagnetism* to distinguish it from *diamagnetism*, a peculiar magnetic property possessed by bismuth and antimony which tends to cause them to lie at right angles to the lines of force. These effects being exhibited by a small bar of the substance free to turn in the magnetic field.

Ferro-manganese Alloys.—Alloys which have a power of electrical resistance unaffected by variations of temperature, employed in making wire for resistance coils.

Ferrule.—A cylindrical ring driven into the end of boiler fire tubes to fasten them tightly in the tube plates.

Fettling.—1. The process of cleaning or dressing castings.

2. The materials used as a bottom lining for a puddling furnace hearth: (1) "mill scale" or black oxide of iron as found around an anvil or formed upon bars and plates as they are rolled; (2) "bulldog," a mixture of ferrous silicate and ferric oxide, produced by roasting the *tap cinder* or slag of a previous puddling, together with the scale beaten out of the bloom as it is shingled under the hammer.

Fiber.—1. One of the delicate, thread like or string like portions of which the tissues of plants and animals are in part constituted; as, the fiber of flax or of muscle.

2. Any fine, slender thread, or thread like substance; as, a fiber of spun glass.

Fiber Suspension.—A delicate method of suspending a needle for sensitive movements, as in a galvanometer, by a filament of silk or fiber of quartz; torsion suspension.

Fibrone.—A compound for insulating purposes.

Fiducial Line or Point.—A line or point of reference assumed as a fixed basis of comparison.

Field.—A term applied to the space occupied by electric or magnetic lines of force.

Field Bore.—The open spaces between the pole faces of the field magnets of a dynamo in which the armature rotates.

Field Coils.—The coils of insulated wire wound upon the field magnets of a dynamo.

Field Control.—The control or regulation by means of a rheostat of the current used to excite an electromagnet, or the regulation of the field current of a motor for varying its speed by means of a rheostat connected into the field circuit.

Field, Cyrus West.—Born 1819, died 1892. An American merchant and financier. At the age of thirty-three he retired from the paper business with a comfortable fortune to turn his energy into broader channels. In 1854, Mr. Field became convinced that the laying of a submarine cable under the Atlantic between Newfoundland and Ireland was a practical possibility, and the same year he organised the New York, Newfoundland and London Telegraph Co. to promote the scheme. The first attempt at laying the cable was made in 1857 and failed. Repeated unsuccessful attempts followed; finally on Aug. 16, 1858, success was achieved and a message was transmitted from Queen Victoria to President Buchanan. The cable, however, broke soon after and Mr. Field's firm went into bankruptcy. But he did not lose heart. The contract was let to an English company, a heavier cable was built, and after a first failure in 1865, the Great Eastern started July 13, 1866, on a triumphant voyage making a land connection on the Newfoundland coast Nov. 27.

Field Density.—The strength of a magnetic or electromagnetic field measured by the number of lines of force it contains in a given cross sectional area.

Field Distortion.—A distortion in the magnetic field of a dynamo caused by the magnetizing action exercised by the current in the armature.

Field, Electric.—The space traversed by lines of electric force.

Field Excitation.—The production of an electromagnetic field in a dynamo or motor by supplying a current for magnetizing the field magnets. This may be done in five ways: (1) by permanent magnets, (2) by separate excitation, (3) by a shunt winding, (4) by a series winding, (5) by a compound winding. Dynamos are classified according as the excitation is supplied from an outside source, or by the machine itself, into *separate* or *self-exciting* dynamos.

Field Frame.—A ring of cast iron or mild steel of suitable diameter and width, standing upright upon the bed plate of a dynamo, and carrying the electromagnets bolted or cast solidly upon its inner circumference.

Field Frequency.—In an alternating current motor, the number of rotations which the magnetic field makes per second.

Field Magnet Coils.—The coils of insulated wire employed to excite the field magnets of a dynamo or motor; the field coils.

Field Magnets.—In a dynamo or motor, strong magnets terminating in pole pieces between which the armature is rotated, the axis of the armature being at right angles to the general direction of the lines of induction of the field. The object of field magnets is to produce an intense magnetic field within which the armature revolves. They may be either permanent or electromagnets. Electromagnets, however, possess such a number of important advantages over permanent magnets that they are now invariably used in all machines intended for practical work. The field magnets of a dynamo may be excited, either by the current furnished by an independent dynamo or battery, in which case the machine is said to be "separately excited," or by the current generated in the armature of the machine of which the field magnet forms part, when the machine is said to be self-excited. The latter type of machine depends for its action upon the presence of residual magnetism in its field magnet. Owing to this residual magnetism, a weak magnetic field is always present between the pole pieces of a field magnet; hence, when the armature is rotated in the armature chamber, its conductors cut the lines of force contained in this magnetic field, and a small E. M. F. is set up in the armature in consequence.

Field of Dynamo.—The region between the pole pieces of a dynamo, within which the armature rotates and the lines of force are generated.

Field of Force.—The space occupied by electric or magnetic lines of force.

Field of Solenoid.—The magnetic field existing inside and throughout the length of a solenoid when an electric current passes through its coils.

Field Poles.—The poles of the field magnets between which the armature of a dynamo or motor rotates.

Field Rheostat.—An adjustable resistance used to vary the strength of the magnetic field of a shunt wound dynamo or motor.

Field Spools.—A name sometimes given to the field coils of a dynamo.

Field Strength.—The strength or intensity of the lines of force in a magnetic field.

Field Telegraph Line.—A telegraph line erected for temporary use in directing army manoeuvers and similar operations.

Field Tube.—In steam engineering, an arrangement of two concentric tubes, which greatly improves the circulation and steaming capacity of a vertical boiler; the heated water rises in the annulus between the inner tube and the exterior heating surface, while the cold water circulates down the inner tube.

Field Windings.—The conducting coils wound upon the field magnets of a dynamo or motor; the field magnet coils. The insulated wire used for the excitation of the field magnets, not being subjected to any of the detrimental influences experienced by the armature conductors, is usually of copper. As a rule, the wire is wound upon insulated spools, which are afterwards slipped over the limbs of the magnet; in some cases, however, the winding is direct upon the core of the field magnet. this latter being previously insulated with vulcanised fibre or other insulating material.

In general, the wire used for the exciting coils of shunt wound dynamos is very thin; hence, it is very liable to break off near the flanges of the reel upon which it is wound. Several plans are adopted to prevent this occurring: in some cases the ends of the shunt coils are soldered to stouter wires within the flanges of the bobbins, these wires being afterwards connected to the terminals of the machine: in other cases, the ends of the coils are soldered to large terminals fixed upon the flanges of the bobbins, these terminals being afterwards suitably connected together by strips of copper.

Fifth Wheel.—A horizontal wheel-like bearing or pivot supporting the front axle of a vehicle, enabling it to be revolved at an angle for turning corners; by the arrangement of a worm gearing, the fifth wheel can be made to serve as a steering gear.

Fig.—Abbreviation for figure.

Figure.—A character standing for, or representing a number; a numeral; a digit; as, 1, 2, 3, etc.

Figure of Eight Wire.—A form of trolley wire having a cross section resembling the shape of the numeral 8.

Figure of Merit.—The value of the electric current required to produce a deflection of one degree or one division upon a galvanometer scale.

Figures, Electric.—1. The distribution in the form of curious figures which takes place when certain electroscopic powders are sifted over a charged surface, illustrating the distribution of electricity over the surface.

Filament.—A thin wire, untwisted thread, or fiber.

Filament of Incandescent Lamp.—The thin wire or filament of infusible conducting material within the bulb of an incandescent lamp.

Filament Shadows.—The blackening of the inner surface of an incandescent lamp bulb by the depositing of carbon from the wasting filament.

Filings.—The particles of metal, such as iron or brass, produced by the action of a file or rasp.

Filings Coherer.—In wireless telegraphy, a coherer employing nickel and silver filings.

Filings Tube.—In wireless telegraphy, a coherer tube containing nickel and silver filings. When the electric impulse arrives the filings cling together, or cohere, and thus complete the circuit.

Filling.—Anything that stops up a hole or vacant space. In civil engineering, the embankment made on low ground to bring the road up to the required level.

Film.—A very thin skin, membrane or layer.

Film Cut Out.—An automatic cut out consisting of a paper film set between the terminals of a series incandescent lamp, designed to short circuit the current and cut out the lamp when the filament breaks.

Film Lightning Arrester.—A lightning arrester provided with a cut out consisting of a paper or mica film.

Filtering.—Various mediums are used in the process of filtration: charcoal and bone black when it is desired to retain or remove certain gases, etc., sand or gravel

for rough filtration in large quantities, and silica or sponge for fine work.

Filtration.—The passing of a liquid through a filter or cleansing medium for the purpose of removing impurities or other undissolved solids.

Final Cable Splice.—The finishing splice in a cable.

Final Cable Test.—The final test applied to a cable after it has been laid, to see if it meets all requirements.

Final Pressure.—In steam engineering, that pressure which would exist in the cylinder of an engine if the expansion were continued to the end of the stroke instead of being interrupted by *pre-release.* It is usually called *terminal pressure;* its intensity depends on the initial pressure, ratio of expansion, and amount of condensation.

Finding Earth.—The act of grounding a telegraph circuit.

Fine Metal.—In smelting, *matte* which is obtained from the fusion of calcined coarse metal, such as copper or slags and ores.

Finished Surfaces.—Those portions of a piece of machinery which are machined or filed to a smooth polished surface; either for jointing where one part abuts on another, or for the sake of appearance. A *machined* surface is one where smoothness or high polish is not demanded, the work being left with minute ridges and tool marks, which would be removed in finishing.

Finishing Brushes.—Fine brushes employed for polishing a metal after it has been electroplated.

Fire.—The evolution of light and heat in the combustion of bodies, or that active natural process by which burning bodies are decomposed with the evolution of heat and light; combustion; state of ignition.

Fire Alarm.—An apparatus for giving or communicating an alarm of fire; as, by telegraphic signals. When of the automatic type the operation depends on the action of *thermostats*, placed in the circuit at various points; these are affected by a change of temperature, hence on being heated they close the circuit which causes the alarm to sound.

Fire Alarm Annunciator.—An annunciator for use in a fire alarm system.

Fire Alarm Contact.—A contact so adjusted as to give an alarm of fire when heated to a certain point.

Fire Alarm Signal Box.—A signal box conveniently located for turning in a fire alarm.

Fire Alarm Telegraph.—A system of telegraphy for sending fire alarms from signal boxes located at convenient points along the line.

Fire Ball.—A rare form of lightning in which a ball of fire is seen to run along a surface or float in the air and finally burst; globular lightning.

Fire Bars.—The bars on which the fire rests in the furnace of a steam boiler.

Fire Brick.—A refractory brick, capable of sustaining intense heat without fusion, composed largely of fire clay.

Fire Cleansing.—Subjecting metal to the action of fire in order to remove surface impurities before electroplating.

Fire Extinguisher, Electric.—A thermostat which, upon a given increase of temperature, completes an electric circuit by means of which water is turned on in case of fire.

Fire Glow.—A name given in early times to the aurora.

Fireproof.—Incombustible; proof against fire.

Fire Surface.—The heating surface of a boiler, subject to the action of flame and hot gases.

Fire Telegraph.—A system of telegraphy for sending fire alarms to an engine house from signal boxes located at convenient points along the street.

Fire Tube Boiler.—A term representing a class of multi-tubular boilers in which the inside of the tube is exposed to the fire and gases from the furnace, as distinguished from water tube boilers.

Firing Battery.—A battery suitable for firing a fuse in order to explode a blast, or a submarine or land mine.

Firing Filament.—Carbonizing a filament in order to render it fit for use in an incandescent lamp.

Firing of Steam Boilers.—This comprises three things: (1) The preparation, which includes the partial filling with water and the kindling of the fire, (2) the running, embracing the feeding, firing, and extinction or banking of the fire, (3) the cleaning out after it has been worked for some time. Before lighting the fire under a boiler the engineer or fireman should make a rapid yet diligent examination of various things, viz.: (1) He should make sure that the boiler has the right quantity of water in it; that it has not run out during the night or been tampered with by some outside party; very many boilers have been ruined by neglecting this first simple precaution. (2) He should see that the safety valve is in working order; this is done by lifting by rod or hand the valve which holds the weight upon the safety valve rod. (3) He should open the upper gauge cock to let out the air from the boiler while the steam is forming. (4) He should examine the condition of the grate bars and see that no clinkers are left from the previous firing.

First Rate Subscriber's Board.—In telephony, a switchboard which handles the business of the first rate subscribers, or those who have independent lines, as distinguished from subscribers on party lines.

Fished Wires.—Wires that have been drawn through ducts by the process of *fishing.*

Fishes, Electric.—Certain fishes which have the power of giving electric shocks in a greater or less degree; as, the *electric eel.*

Fishing.—A method of running wires through walls, floors and ducts by the aid of other wires attached to the conductors and threaded and drawn through in advance.

Fishing Box.—In a conduit system of wiring, a name sometimes given to a junction box at which splices may be made and wires may be "fished" through.

Fishing Process.—In electric wiring, the process of *fishing* conductors into place.

Fish Joint.—A splice consisting of one or more pieces of iron or wood bolted to the side or sides of two adjacent rails, where the head of one meets the foot of the other; a fish plate.

Fish Plate.—In an electric railway, the metal plate which joins one rail to another.

Five Point Branching Jack.—A five contact spring jack employed in the switchboard of the branch terminal telephone system.

Five Point Jack.—A telephone spring jack provided with five contacts for use in a multiple switchboard.

Five Wire System.—A system of electric distribution based upon the principle of the *three wire* system, having in this case five conductors leading from series connected dynamos.

Fixed Electric Lamp.—An electric lamp attached to a stationary fixture.

Fixed Resistance.—A resistance having a constant known value.

Fixture Cut Out.—A cut out suitable for an electric light fixture.

Fixture, Electric.—The fittings required in the installation of an electric lamp; more specifically the lamp bracket or electrolier.

Fixture Wire.—A variety of insulated wire adapted to lamp fixtures.

Flag Signaling.—A method of signaling by means of a small flag which is waved to the left and right to indicate the dots and dashes of the telegraphic code;wig-wagging.

Flake of Cable.—One loop of a horizontally coiled cable.

Flame.—The burning of gas or vapor which is given off from the combustion of a solid or liquid substance. By luminous flame is generally meant that which burns with a bright yellow to white color. All flame under a steam boiler is not luminous, sometimes the whole or a part of it will be red or blue.

Flaming Arc Lamp.—An arc lamp of high efficiency in which the carbons are impregnated with a combination of metallic salts which cause a long arc to flame with intense brilliancy. The length of the arc may be five times as great as with ordinary carbons. The source of light is no longer solely the incandescence of the carbon points but chiefly the luminous arc between the points, which are placed converging downward, so that almost uniform illumination is obtained in all directions.

Flaming of Arc.—1. The brilliant light produced between the electrodes of a flaming arc lamp.

2. A flaming or flickering of the arc which takes place when the distance between the carbons of an ordinary arc lamp becomes too great.

Flash.—1. A sudden and transient blaze ot flame or bright light; as a flash of lightning.

2. To treat a carbon filament by flashing, *i. e.*, by depositing additional carbon at such parts as exhibit the greatest resistance to a current.

Flashed Filaments.—Carbon filaments which have been prepared for incandescent lamps by the process of *flashing*.

Flashing.—A process of perfecting the carbonization of the filament of an incandescent lamp, whereby a final layer of surface carbon is applied by momentarily heating the filament electrically to a white heat in a carbonaceous atmosphere.

Flashing Lights.—Lights, especially those in lighthouses, displayed in intermittent flashes.

Flashing of Dynamo.—Flashing or *sparking* which is liable to take place at the brushes of a commutator. It may arise from bad adjustment or condition of the brushes, bad condition of commutator, overload of dynamo, loose connections, disconnections or short circuits in armature circuit, and similar causes. When sparking occurs at the brushes of a good dynamo, two kinds may generally be distinguished by the experienced eye, viz., those sparks due to bad adjustment of the brushes, generally of a bluish color, small when near the neutral points, and increasing in violence and brilliancy as the brushes recede from the correct positions upon the commutator; and those due to a dirty and neglected state of the commutator and brushes, these being distinguished by a reddish color and a spluttering or hissing. When due to this last-mentioned cause, it is impossible to suppress the sparking until the commutator and brushes have been cleaned up. In the former case, the sparks will disappear as soon as the brushes have been rotated into the neutral points.

Flashing Over.—In dynamos furnishing high pressure current, the drawing out of a long blue spark from brush to brush on the commutator, when the resistance of the circuit is suddenly changed.

Flash Light.—A type of lighthouse or signal light in which the rays are rendered intermittent by being alternately obscured and revealed.

Flash Point of Oil.—The temperature at which oil gives off explosive vapors. It is determined by heating the oil with a thermometer immersed in it, and applying a flame as the temperature rises. Sometimes the oil is heated in shallow cups of a specified size, and a taper is passed over the surface to cause ignition; this is termed the "open flash" test.

Flash Signaling.—A method of signaling by intermittent flashes of light.

Flash System of Gas Lighting.—A system of gas lighting used in large auditoriums where there are many groups of jets. Each burner is furnished with two insulated sparking points so adjusted that an electric spark between them passes across to the tip and lights the gas.

Flat Board.—A telephone switchboard which lies in a horizontal position instead of standing upright.

Flat Cable.—A cable made up of conductors laid side by side to permit of resting closely against a wall or ceiling.

Flat Commutator Segment.—A commutator bar that has become flattened or pitted by wear or some fault in adjustment.

Flat Duplex Cable.—A flat cable made up of two parallel conductors.

Flat Iron, Electric.—A domestic flat iron heated by an electric current.

Flat Ring Armature.—An armature having a core shaped like a broad flat ring.

Flats.—The points upon the surfaces of commutator segments, which, through wear or faulty adjustment, have become worn away so as to form slight depressions. It is not confined to dynamos of bad design or construction, but frequently appears on those of the highest class, and may be recognized as a "pitting" or "flattening" of one or more segments. It is always accompanied by sparking at the brushes, and may be due to a periodical jumping of the brushes, caused by a bad state of the commutator, or a bad joint in the driving belt, or to a flaw, or a difference in the composition of the metal of the particular bar upon which it appears. But more frequently it may be traced to a more or less developed fault, such as a disconnection, either partial or complete, in the armature coil. The disconnection may occur either in the coil itself, or at the point where its ends make connection with the lug of the commutator, or at the point where the lug is soldered to the segment of the commutator.

Flaw.—A defect or imperfection; a crack in otherwise solid metal.

Fleeting Knife.—A device on a cable laying machine for guiding the cable over the drum.

Fleming's Rule.—A rule for determining the direction of the induced current in a circuit. It may be expressed as follows: Hold the thumb and the first and the middle fingers of the right hand as nearly as possible at right angles to each other, so as to represent three rectangular axes in space: if the thumb points in the direction of the motion of the conductor, and the forefinger points along the direction of the magnetic lines, then the middle finger will point in the direction of the induced electromotive force.

Flexible Conduit System.—An underground conduit system constructed in such a manner as to permit of the introduction of wires at any time.

Flexible Electric Heater.—A flexible device for applying electric heat to various parts of the human body in medical practice.

Flexible Lamp Cord.—A cord composed of insulated flexible conductors, twisted together and serving as a pendant or other connection for an incandescent lamp.

Flexible Lead.—Any electrical conductor that is so stranded as to be readily bent.

Flexible Pendant.—An incandescent lamp pendant composed of its own flexible conductors.

Flexible Shafting.—A pliant shaft, much used for driving drills and which may be connected directly to an electric motor; a shaft composed of a number of concentric spiral coils of wire, wound alternately right and left.

Flexible Twin Lead.—A lead composed of two flexible conductors running parallel.

Flexure.—In mechanics, a term sometimes applied to the bending of a beam under a load. It is measured either by the deflection of a given point in the beam from a straight line, or by the curvature which it acquires under the action of the load.

Flicker Photometer.—A type of photometer in which rotating mirrors or diffusing screens are employed in order to give rapidly alternating impressions from both lamps. By increasing the speed of rotation, the two lights appear to flicker and the flickering is more pronounced the greater the difference of the luminous intensities of the lamps under comparison.

Float Feed Carburetter.—A carburetter for internal combustion engines, in which a cork or hollow metal float controls the height of the gasoline or other liquid fuel in the receiving or float chamber.

Floating Battery.—A storage battery employed in a parallel system to discharge into or be charged by the system as required.

Float Trap.—In steam engineering, a trap in which the rise of the level of the water of condensation raises a ball, which operates a valve to discharge accumulated water.

Float Valve.—An automatic valve in which the admission of water into a tank or vessel is controlled by a lever attached to a hollow sphere, which floats on the surface and opens or closes the valve, according to its position.

Flogging Hammer.—A medium sized sledge hammer such as used by erectors and machinists.

Floor Chisel.—In wiring, a wide rod chisel used by electricians for cutting through floors. It is usually 18 to 24 inches long, and must not be used for prying up boards, the *ripping chisel* being employed for that purpose.

Floor Contact.—An electric contact set in the floor and operated by a pressure of the foot.

Floor Push.—A press button for ringing an electric bell, so constructed that it may be set into the floor and operated by pressing with the foot.

Flour of Sulphur.—In steam pipe fitting and wiring, a fine flour made of sulphur; this mixed with sal ammoniac and iron borings is used for making rust joints.

Flow.—The amount of a fluid in motion that passes any point in a given time; as a flow of electricity.

Flow of Electro-static Flux.—The movement of electrostatic flux along a conductor, giving rise to the electric current.

Flow of Energy.—The movement of energy along a conductor, giving rise to the electric current.

Flow of Heat.—The passage of heat through a conducting substance under conditions of varying temperature.

Flow of Magnetic Flux.—The passage of lines of magnetic force through a magnetic circuit.

Fluctuating Current.—A current varying in strength and pressure.

Fluid Depolarizer.—A liquid added to a primary cell to prevent polarization. The Daniell and Grove types of cells employ fluid depolarizers, the former using a solution of copper sulphate, and the latter nitric acid or bichromate of potash.

Fluid, Electric.—A term formerly applied to electricity in accordance with the now rejected theory that electricity is actually a material fluid existing in all bodies.

Fluid Insulator.—An oil insulator sometimes used for high potentials.

Fluidity.—The quality of being fluid or capable of flowing; that quality of bodies which renders them impressible to the slightest force, and by which the particles easily move or change their relative position without a separation of the mass; a liquid, aëriform, or gaseous state; opposed to solidity.

Fluid Pressure.—In mechanics, pressure is transmitted by fluids *in all directions with an equal pressure.* The intensity of this pressure at any point within the fluid is proportional to the depth of the point from the surface of the fluid.

Flume.—A passage or conduit for the water that drives a mill wheel, or an artificial channel of water for hydraulic mining; also a chute for conveying logs or lumber down a declivity. In mining, an open or covered conduit for water, generally timber built, and carried on trestle work.

Fluorescence.—The property possessed by some transparent bodies of becoming luminous from light previously absorbed by them. In fluorescence, light is transformed by the invisible rays beyond the violet and ultra-violet becoming visible, the particles absorbing one wave length and emitting another. Fluorescence may be said to be a form of *phosphorescence.*

Fluorescent Screen.—A screen coated with fluorescent matter employed in a fluoroscope for X-ray work.

Fluorimeter.—A name sometimes given to the fluoroscope.

Fluorograph.—The picture cast upon a fluorescent screen of an object through which X-rays are passed.

Fluoroscope.—An opaque box or tube having at one end a screen coated with fluorescent material, for the purpose of exhibiting the shadows cast by the X-rays.

Fluoroscopic Examination.—An examination of the human body by the use of the X-ray in connection with the fluoroscope.

Fluoroscopic Screen.—A fluorescent screen employed in the fluoroscope.

Fluoroscopy.—The examination of the human body by the use of X-rays in connection with the fluoroscope; *cyptoscopy.*

Flush Bolt.—A screw bolt whose head is countersunk, so that it will not protrude from the surface.

Flush Box.—In an underground conduit system, a box or opening sunk flush with the street level for the purpose of permitting an examination of the conductors, or the introduction or removal of wires from the conduit.

Flush of Current.—The excessive rush of current which enters an arc lamp at the moment of starting.

Flush Plate.—A plate provided with flush push buttons.

Flush Push.—A push button set flush with the surrounding surface.

Flush Switch.—A key switch so placed as to be flush with the surface of the wall or woodwork on which it is mounted.

Fluviograph, Electric.—An electrical instrument for measuring and recording automatically the rise and fall of level in a river or other body of water.

Flux.—1. In melting metals, an addition of some mineral, generally limestone or chalk, to the charge in the furnace, for the purpose of absorbing mineral impurities in the metal and running them off as the slag.

2. In soldering or brazing, a substance applied to the portions to be united, causing the solder to flow easily and adhere to the joint.

3. A general term for *electrostatic* or *magnetic flux.*

Flux Density.—The number of magnetic lines that run through a unit area of cross-section of a magnetized substance.

Flux Horn.—One of the projecting edges of the pole pieces of a dynamo which extend in the direction of the armature; the *leading horn.*

Flux Intensity.—The flux density of a magnetized substance.

Flux Leakage.—Any dissipation or loss of electrostatic or magnetic flux.

Flux Magnetism.—The magnetic flux, being the total number of lines of force passing through a magnetic circuit. It is equal to the product of the magnetic density by the cross section area. Flux magnetism is also known as *magnetic flow.* The following definition of magnetic flux is that given by a committee of the American Institute of Electrical Engineers on "Units and Standards": "The magnetic flux through a surface bounded by a closed curve is the surface integral of magnetic induction taken over the bounded surface, and when produced by a current is also equal to the line integral of the vector potential of the current taken round the boundary."

Flux of Heat.—The amount of heat flowing through a given distance in a given time.

Flux of Light.—The amount of light passing through a certain area in a given time; *quantity of light.*

Flux of Magnetic Induction.—The flowing of magnetic induction.

Fly or Flyer, Electric.—A light, delicately poised wheel with radiations terminating in points bent at right angles in the same direction; when connected with a source of electricity, it spins rapidly on account of the discharge of convection streams from the points resisting the surrounding air; *a reaction wheel.*

Flying Break of Armature Conductor.—A break in an armature winding that can be seen only during the rotation of the armature.

Flying Cross.—A fault liable to occur in the armature of a dynamo or motor, due to a loose wire that causes trouble only when the armature is in rotation. If not located, the fault will finally burn through the armature insulation.

Flying Soundings.—Soundings that may be taken in water not over two hundred fathoms deep while the vessel is moving at the rate of five or six knots an hour.

Fly Wheel Alternator.—A term sometimes applied to an alternator in which the armature conductors are wound in slots on the inside face of the laminated core, while the field magnet system is built upon the rim of a massive fly wheel which revolves within the bore of the armature.

Foaming in Boilers.—The mixing of steam and water in boilers accompanied by violent ebullition. The causes are: dirty water, trying to evaporate more water than the size and construction of the boiler is intended for, taking the steam too low down, insufficient steam room, imperfect construction of boiler, too small a steam pipe, and sometimes it is produced by carrying the water line too high.

Focal Distance.—The distance from the center of a mirror or lens to its focus.

Focimeter or Focometer.—An instrument for finding the focus of a lens or a combination of lenses.

Focus.—1. The point of concentration.

2. A point at which rays of light meet, or seem to meet, after passing through a lens or being reflected from a mirror.

Focusing Arc Lamp.—An arc lamp having both carbons automatically movable at their respective rates of consumption so as to maintain the arc at the focus of a lens or reflector; an important consideration in lighthouse and lantern work.

Focus Rays.—A term applied to the Roentgen or X-rays; a peculiar radiation produced in a high vacuum tube whenever cathode rays strike some solid substance, the method employed is to apply a high tension current to a vacuum tube having electrodes sealed in its ends.

Focus Tube.—A device for the production of X-rays, consisting of a glass tube with

electrodes sealed in the ends and having the air exhausted as completely as possible, the efficiency of the tube depending on the degree of vacuum.

Fog, Electric.—A fog which sometimes arises when the atmosphere contains an unusual amount of free electricity.

Foil Brush.—A dynamo or motor commutator brush composed of metallic foil, especially copper foil.

Foiled Conductor.—A conductor having an outside coating of tin foil.

Following Horns.—The projecting edges of the pole-pieces of a dynamo which extend in a direction opposite to the rotation of the armature; the poles towards which the armature turns.

Fool Proof.—A term applied to any machine, instrument or device that is so safeguarded in its construction that an ignorant or incompetent person cannot easily inflict injury upon it or suffer injury from it by careless handling.

Foot.—1. The lower part or foundation; the ground part; the bottom; as, of a column.

Foot Candle.—A unit of illumination, being the light of a standard candle at the distance of one foot.

Foot Grain.—A section of wire one foot in length and weighing one grain, taken as *a unit in measuring resistance.*

Foot Pound.—A unit of work or energy; it is the work done when a weight of one pound is raised to the height of one foot.

Foot Pound per Second.—A unit of activity; it is the expenditure of one foot pound of energy in a second of time.

Foot Switch.—A switch so situated as to be controlled by the foot.

Force.—An influence exerted upon a body so as to produce a change, or a tendency to change, in its state of rest or motion.

Forced Draught.—In steam engineering, a system of artificial draught in which air is forced through the fires to accelerate combustion, thus increasing the boiler horse power.

Forced Vibrations.—Vibrations which a vibrating body tends to set up in other bodies near it, even though their periods of vibration are different.

Force Fit.—A shop term for that class of fit where a shaft is turned so much larger than its hole that a screw or hydraulic press, or the application of heat to the female piece is necessary to get the pieces together.

Forebay.—The end of a mill race, next the wheel, or that part of a race above the flume or chute of a turbine water wheel.

Forge, Electric.—A furnace in which the metal to be worked is heated by electricity.

Fork.—Anything like a fork in shape, also one of the parts into which anything is bifurcated or divided; a prong; a point; a mine is said to be in fork, or an engine to have the water in fork, when all the water is drawn out.

Forked Circuits.—A number of circuits which diverge from a central point, being one of the methods of wiring employed in telegraphy.

Forked Lightning.—A form of lightning discharge which seems to split into branches or to follow a zigzag path; zigzag lightning.

Form.—The shape and structure of anything, as distinguished from the material of which it is composed; configuration; figure; frame; external appearance.

Formal Inductance.—The self induction in an electric circuit due to the form of the circuit.

Formed Armature Windings.—Armature coils that are wound upon a form and then transferred to the armature core.

Formed Plates.—Lead plates prepared for use in secondary cells.

Former.—A template or shape sometimes used for winding armature coils before placing them on the armature core.

Forming Block.—In a multiple telephone switchboard, a block employed to hold spring jack connections before joining them up with the line conductors, preparatory to fitting them into the switchboard.

Forming Process.—The preparation of the lead plates of a storage battery in which they are subjected repeatedly to the action of reversed currents while immersed in dilute sulphuric acid, until the anode plate becomes coated with a semi-porous film of brown dioxide of lead and the cathode plate assumes a spongy metallic state.

Formula.—1. A prescribed form, principle or rule expressed in mathematical terms, chemical symbols, etc.

2. An arithmetical formula is a general rule of arithmetic expressed by signs. Formulas or formulæ express the plural of formula, a Latin word which means, simply, a form; hence, a formula is a form of stating a problem.

Form Wound Coil.—An armature coil prepared upon a form to the shape of an irregular rectangle so as to exactly fit the place intended for it upon the armature core.

Forward Induction. — Induction that tends to aid the electromagnetic field, as distinguished from *back* induction which opposes it.

Forward Lead of Brushes.—A displacement of the brushes upon the commutator of a dynamo armature in advance of the position at right angles to the line connecting the poles of the field magnet; also called *positive lead.* In a motor the brushes are set back of the right angle; that is, they are given a *negative lead.*

Forward Pitch of Armature Winding.—A right hand pitch as regarded from the commutator end.

Foucault Currents.—Stray currents which are liable to be set up in the core of an armature, because the iron of the core cuts the flux in the same manner that the windings do. To prevent these local currents, usually known as *eddy* currents, the armature is built up of laminations consisting of thin stampings of steel.

When the construction of the armature core and conductors does not fulfil the necessary conditions required for the prevention of eddy currents, such as the laminations not being sufficiently insulated or numerous enough, a great heating of the whole of the armature results, which may even extend to the bearings. There is no remedy for this defect other than the purchase of a new armature, or the entire reconstruction of the old. The fault may be detected by exciting the field magnets and running the machine on open circuit, with the brushes raised off the commutator for some time, when the armature will be found to be excessively heated.

Foucault, Jean Bernard Leon.—Born 1819, died 1868. A French scientist and inventor, noted for his optical researches and his investigations in connection with eddy currents in an electromagnetic field.

Foucault Losses.—Losses of electric energy occurring in a dynamo or motor because of Foucault or eddy currents.

Foundation.—The base upon which anything is erected. The lowest part of a building, usually below the street level.

Foundation Frame.—One of the component parts of a motor or dynamo, consisting of a bed plate or base upon which the coils are erected, and having arms or standards which carry the main bearings.

Foundation Ring.—In dynamo armature construction a ring-shaped core upon which are placed the windings of armatures of the Gramme ring type; usually called *Gramme ring.*

Fountain, Electric.—A fountain operated by electricity, and illuminated by colored electric lights.

Fountain Projector.—A projector for throwing the light of an arc lamp into an electric fountain.

Four Conductor Cord.—A conductor cord made up of four insulated wires.

Four Cycle.—In gas engines, the cycle of operations occupying *four strokes* or *two complete revolutions.* On the first forward stroke, an explosive mixture of gas and air is brought into the cylinder by suction, and compressed by the return or second stroke. The mixture is ignited by an electric spark just before the completion of this stroke. The resulting explosion produces a high pressure within the cylinder, which causes the *impulse* during the third or *power stroke;* on the return or fourth stroke, the products of the combustion are exhausted into the air, completing the *cycle.*

Fourneyron Turbine.—A radial outward flow water wheel, consisting of a fixed wheel with guide plates, in which the water acquires a rotary motion before entering the movable wheel, which it causes to rotate by pressure or reaction on curved vanes. The turbine rotates in a horizontal plane with a vertical spindle.

Four Piece Electromagnet.—An electromagnet built up of four pieces, viz.: the two cores, the yoke and the armature.

Four Point Switch.—A switch provided with four electrical contacts; a four pole switch, or four way switch.

Four Pole Dynamo.—A multipolar dynamo having its magnetic field generated by four poles.

Four Speed Regulator.—A regulator providing for four different rates of speed.

Fourth Dimension.—A term used in measurements; an extension of the conception of the three dimensions, length, breadth and thickness. The calculations relating to the fourth dimension belong exclusively to higher mathematics and are based upon assumptions rather than direct measurements. Thus, it is assumed. (1) that space is extended in length, breadth and thickness without limits, also without properties dependent either upon position or direction, (2) that this space is affected with such curvature that a right line shall always return into itself at the end of a finite and real distance without losing in any part of its course that symmetry with respect to space on all sides of it, which constitutes the fundamental property of our idea of it.

Fourth State of Matter.—A condition of matter which Sir William Crookes in his experiments with vacuum tubes thought to be a fourth state, and which he designated "radiant" matter, being still more diluted than in the gaseous state. This matter is now thought to be made up of particles known as electrons which are about 200,000 times smaller than ordinary atoms.

Four Way Cock.—A cock so designed that water or liquids may be diverted into four different discharge pipes.

Four Way Splice Box.—In underground cable construction, a splice box furnished with four channels or ducts for lateral connections.

Four Wire System.—A system of electric distribution based upon the principle of the *three wire* system, having in this case four conductors leading from three dynamos.

Four Wire Transmission.—The four wire system of electric distribution.

Four Wire Two Phase Circuit.—A circuit consisting of four separate wires for the transmission of two phase currents.

Fractional Distillation.—A process of distillation by which a solution containing a mixture of liquids having different boiling points may be separated into its constituents by increasing the heat, step by step, according to the varying degrees of volatilization.

Fractional Electrolysis.—Electrolysis of one substance after another by the application of electromotive force in increasing proportions.

Fracture.—1. The act of breaking or snapping asunder.

2. The appearance of a freshly broken surface, by which its texture is displayed; as, a compact fracture; a fibrous fracture.

Franklin, Benjamin.—Born 1706, died 1790. An American scientist, philosopher and statesman. He demonstrated the identity of lightning with electricity by his famous kite experiment (1752), and as a result invented the lightning rod; observing the waste of heat in open fire places he devised the Franklin stove; he constructed a lamp which anticipated the principle of the Argand burner; he improved the printing press, invented double spectacles and made many other inventions that contributed to the advancement of mankind.

Franklinic Currents.—Currents generated by a frictional machine.

Franklinic Electricity.—Frictional or static electricity as employed in electrotherapeutics.

Franklin Institute System of Screw Threads.—The *Sellers* standard scale of screw threads, in which the characteristic is that the angle of the sides is 60°, and $\frac{1}{8}$ of the thread is flat at top and bottom; this varies from the Whitworth scale, in which the angle is 55°, and $\frac{1}{6}$ of the thread is rounded at top and bottom.

Franklinization or Franklinism.—In electro-therapeutics, the application of franklinic or frictional electricity.

Franklin's Kite.—A kite by which Benjamin Franklin established the identity of lightning and electric discharge. In 1749, he noticed lightning to possess almost all the properties observable in electric sparks, and suggested that the electric action of points, which was discovered by him, might be tried on thunderclouds, and so draw from them a charge of electricity. He proposed, therefore, to fix a pointed iron rod to a high tower, but shortly after succeeded in another way. He sent up a kite during the passing of a storm, and found the wetted string to conduct electricity to the earth, and to yield abundance of sparks. These he drew from a key tied to the string, a silk ribbon being

interposed between his hand and the key for safety. Leyden jars could be charged, and all other electrical effects produced, by the sparks furnished from the clouds. The proof of the identity was complete. The kite experiment was repeated by Romas, who drew from a metallic string sparks 9 feet long. In 1753, Richmann, of St. Petersburg, who was experimenting with a similar apparatus, was struck by a sudden discharge and killed.

Fraunhofer's Lines.—A large number of dark lines seen in the spectrum of the light of the sun.

Free Charge.—The state of electricity upon a charged conductor when isolated from a charge of opposite sign.

Free Electricity.—A term sometimes applied to the ordinary state of electricity upon a charged conductor, as distinguished from a *bound* charge. A free charge will instantly flow away to earth if a conducting path be provided for it.

Free Ether.—The ether which is assumed to occupy all the great spaces of the universe, as distinguished from that which is conceived to exist within solid bodies.

Free Insulated.—A term applied to a telegraph wire that has been disconnected and insulated.

Free Magnetic Pole.—A pole in a magnetic substance which seems to exist without reference to an opposite pole.

Free Magnetism.—That part of the magnetism of a magnetized body which does not follow the magnetic circuit through the metal, but finds a path from the surface of the magnet through the air; *surface magnetization.*

Free Path.—The path of a molecule of a gas in which it does not come into contact with other molecules.

Free Vibrations.—Vibrations performed by an elastic body after the vibrating force has been removed.

Freezing Point.—The point at which a liquid tends to become a solid by loss of heat. The freezing point of water is 32° F.

Frequency.—The number of double alternations or periods made by an alternating electric current per second; *periodicity.*

Frequency Converter.—A machine for converting from an alternating current system of one frequency to an alternating current system of another frequency, with or without a change in the number of phases or in voltages.

Frequency Meter.—In electric station practice, a special switchboard instrument which indicates the frequency and power-factor of the current. It operates on the principle of the production of a rotary field by means of two mechanically displaced coils carrying electrically displaced currents.

Frequency Setter.—A dynamo which furnishes alternating currents of fixed frequency.

Frequency Teller.—A contrivance for indicating the frequency of an alternating current.

Friable.—Easily reduced to powder; liable to crumble.

Friction.—This is defined by Rankine as "that force which acts between two bodies at their surface of contact so as to resist their sliding on each other, and which depends on the force with which the bodies are pressed together. Morin's laws of friction are as follows: (1) The friction between two bodies is directly proportional to the pressure, that is, the coefficient is constant for all pressures. (2) The cœfficient and amount of friction, pressure being the same, is independent of the areas in contact. (3) The cœfficient of friction is independent of velocity, although static friction (friction at rest) is greater than the friction of motion.

Frictional Electricity.—Electricity generated by friction. The terms frictional-electricity, galvanic-electricity, etc., though convenient for distinguishing their origin, have no longer the significance formerly attributed to them as representing different kinds of the electric force.

Frictional Electric Machine.—An apparatus, often called *influence* machine, for converting mechanical energy into electrical energy for experimental purposes by the friction of a glass plate rotating between leather cushions. Well known machines of this class are the Varley, Holtz, Toepler and Wimshurst machines.

Frictional Head.—In hydraulics, increase or decrease of the pressure of fluids in piping due to their friction upon the sides thereof. Thus, in forcing water through pipes, the friction within the mains augments the head to be overcome by the

pumps, while the friction of water on the sides of a flume, will, to a certain extent, destroy the head of water available for power. Also called *dynamic head.*

Frictional Loss.—In an engine or machine, the energy dissipated in overcoming the friction or internal resistance of the mechanism.

Frictional Torque.—The torque required to overcome friction and produce rotation in an armature.

Friction Gearing.—Any combination of elements used to transmit power or motion by frictional contact. Sometimes used in a restricted sense for friction wheels alone.

Friction Wheels.—Wheels for the transmission of power by frictional contact; made as spur wheels and pinions, or bevel and mitre wheels, the teeth being replaced either by compressed paper fillers, leather or other lining, or plain metallic surfaces.

Fringe of Magnetic Field.—The dissipation of free lines of magnetic flux in regions outside of the magnetic field proper.

Frog Galvanoscope.—The employment of the hind legs of a recently killed frog to illustrate the presence of electricity. The experiment originated with Galvani in 1786 who discovered that when the muscles of the legs touched two dissimilar metals in contact with each other, a contraction of the muscles took place. This was the effect of the inductive action of the electricity of the conductor upon the highly electroscopic organs of the frogs; but Galvani was not sufficiently conversant with this branch of physics to comprehend it, and consequently regarded it as a new phenomenon. He proceeded to submit the limbs of frogs to a course of experiments; for this purpose, he dissected several frogs, separating the legs, thighs, and lower part of the spinal column from the remainder so as to lay bare the lumbar nerves. He then passed *copper* hooks through that part of the dorsal column which remained above the junction of the thighs, without any scientific object, but merely for the convenience of suspending them until required for experiment. It chanced, also, that he suspended these *copper* hooks upon the *iron* bar of the balcony of his window, when to his inexpressible astonishment, he found that whenever the wind or any other accidental cause brought the muscles of the leg into contact with the iron bar, that a similar convulsive kick was produced in the frog's leg.

Front End of Armature.—The end of a dynamo or motor armature upon which the commutator is mounted; the *commutator end.*

Front Stop of Key.—A stop on the front of a telegraph key to restrict its downward movement.

Frost Alarm.—An alarm which rings by an electric mechanism when the temperature falls below freezing.

Frying of Arc.—The peculiar hissing sound which is produced when the carbons of an arc lamp are too near each other; a hissing or noisy arc.

Fulcrum.—A prop or support; that by which a lever is sustained or about which it turns in lifting or moving a body; in the operation of the lever, three points are to be considered, viz.: (1) The fulcrum or point about which the bar turns, (2) the point where the force is applied, and (3) the point where the weight is applied.

Fulgurite.—A tubular mass of vitrified sand supposed to be produced by lightning entering the ground.

Full Arc.—A term sometimes applied to an arc lamp of 2000 nominal candle power.

Full Battery.—In quadruplex telegraphy, the two parts of the battery introduced together to produce the whole power.

Full Contact.—A fault produced in a circuit by the accidental metallic contact of any part of it with a good conductor; a total contact.

Fuller Board.—A fibrous material much harder than paper. It is flexible and durable, and, having good electrical properties, is largely used in insulating the coils of electric machines; also known as *presspahn.*

Fuller Cell.—A very useful type of cell adapted to telephone, telegraph or other intermittent work. The zinc electrode in the shape of a cone is cast at the end of a soft copper wire and rests at the bottom of a porous cup in a dilute solution of sulphuric acid. It is amalgamated by mercury. The carbon electrode is in the outer jar in a solution of *electropoion* which consists of three parts bichromate of potash, one part sulphuric acid and nine parts water.

Fullering.—The caulking of a steam boiler by a round nosed tool, caulking being executed usually by a sharper instrument; the washing and scouring of cloth; as, with fuller's earth.

Full Load.—The greatest load which an electric machine is able to carry effectively.

Full Load Current.—The current delivered by an electric source at its maximum load.

Full Load Efficiency of Motor.—The efficiency of a motor when running under maximum load.

Full Load Efficiency of Transformer.—The relation of the electricity delivered by a transformer, to that received by it under full load conditions.

Full Metallic Contact.—A complete electrical contact of conducting metal.

Fundamental Frequency.—In complex harmonic vibration, the lowest frequency.

Fundamental Units.—Units based upon the three fundamental quantities, *length*, *mass* and *time*. In the C. G. S. system they are the *centimeter*, the *gram*, and the *second*, respectively.

Funnel Antenna.—In wireless telegraphy, an arrangement of the aerial wires in a funnel shaped group at a long distance station for the better appropriation of passing electric impulses.

Furnace.—In a steam boiler, that part designed for the burning of the fuel. The principal parts and appendages of a furnace are as follows: (1) *The furnace* proper or firebox, being the chamber in which the solid constituents of the fuel and the whole or part of its gaseous constituents are consumed, (2) *the grate*, which is composed of alternate bars and spaces, to support the fuel and to admit the air, (3) *the dead plate*, that part of the bottom of the furnace which consists simply of an iron plate, (4) *the mouth piece*, through which the fuel is introduced and often some air. The lower side of the mouth piece is the dead plate.

Furnace, Electric.—A furnace heated by electricity for performing difficult or unusual fusions, especially in metallurgical processes. Heat is obtained from the voltaic arc.

Fuse.—A strip of fusible metal, often consisting of lead with a small percentage of tin, introduced into an electric circuit as a protection against excessive current. When the temperature exceeds a certain limit, the fuse "blows" and opens the circuit. Fuses should be placed wherever the size of wire changes or wherever there is a branch of smaller size wire connected, unless the next fuse on the main or larger wire is small enough to protect the branch or small wire, but more lights may be added on the large wire, making it necessary to put in a larger. Experiments have shown that for large fuses, a multiple fuse is more sensitive than a single one. A one hundred ampere fuse may be made by taking four wires of twenty-five amperes capacity. A fuse block may be overloaded, not because the metal of the terminals is not of sufficient cross-section to carry the current, but because of insufficient area of, or loose contact of, fuse, or wires, and this heating is very frequently the cause of fuses melting.

Fuse Alloy.—An alloy of lead with a small percentage of tin, used for electric safety fuses because it readily melts under the heat of an electric current when the current becomes too strong for the safety of the circuit.

Fuse Block.—A block of porcelain or other non-conducting material upon which one or more safety fuses are mounted.

Fuse Board.—A slab of slate upon which safety fuses are mounted.

Fuse Links.—Links of fusible material designed for safety fuses.

Fuse Panel.—A panel upon which fuses are mounted.

Fuse Wires.—Fusible material in various forms for use as safety fuses.

Fusible Alloy.—An alloy which will melt at a comparatively low temperature, employed for safety fuses in electric circuits and for the filling of safety plugs in boilers. An alloy of one part tin, two of bismuth and one of lead will fuse at 100° C.

Fusible Arrester.—A safety fuse.

Fusible Plug.—In steam engineering, a piece of easily melted alloy, placed in one of the sheets of a steam boiler and intended to melt and allow the blowing off of the steam in case of low water.

Fusible Protector.—A safety fuse employed as a line protector.

Fusing Current.—The current required to melt a safety fuse.

G.—1. A signal in telegraphy for "go ahead."

2. An abbreviation for *gram*, the unit of mass in the Centimeter Gram Second system.

3. The symbol for the unit of conductance. The *mho*.

Gain.—A broad notch cut into a telegraph pole to accommodate the cross arms; also a steel channel sometimes employed for the same purpose to save cutting the pole.

Gain Plate of Voltameter.—The plate in a metal voltameter at the cathode, and hence the one on which the metal dissolved from the anode is deposited, increasing its weight.

Galena.—A bluish gray mineral, from which most of the lead of commerce is obtained; native sulphide of lead; used in the form of a powder to glaze pottery.

Galvani, Luigi.—Born 1737, died 1798. An Italian physician and physiologist noted as the discoverer of galvanic or current electricity. While dissecting the legs of a frog, they came by accident into contact with dissimilar metals which caused muscular action in them. Galvani thought that he had discovered electricity in animal matter. Volta attributed the action to the metallic contact and thereupon constructed his voltaic pile, the forerunner of the primary cell.

Galvanic Adapter.—A device for deriving from an electric light circuit weak continuous currents adapted for use in medical treatment.

Galvanic Arc.—An occasional and unusual term for voltaic arc.

Galvanic Battery.—A name sometimes given to a primary battery.

Galvanic Cabinet.—A wooden case containing a voltaic battery and a complete outfit for the medical application of electricity.

Galvanic Cautery.—A method of searing the flesh in medical treatment by the heat of an electric current; an electric cautery.

Galvanic Cell.—A name sometimes given to a primary or voltaic cell.

Galvanic Couple.—Two dissimilar metals associated together as elements in an electrolytic cell for the generation of electricity, as zinc and carbon electrodes of a primary cell; a voltaic couple.

Galvanic Dosage.—Electro-therapeutic dosage; the amount and duration of electrical treatment administered to a patient.

Galvanic Electricity.—An occasional and unsatisfactory term for voltaic electricity.

Galvanic Excitability.—In electro-therapeutics, the electric excitability of nerve or muscular tissue.

Galvanic Fluid.—An early name for the electric current, given in honor of Galvani who discovered current electricity in 1786 as the result of his famous experiments with the legs of a frog.

Galvanic Irritability.—Contractions of muscular tissue caused by an electric current.

Galvanic Multiplier.—A name formerly given to the galvanometer.

Galvanic Pile.—A name sometimes given to the apparatus devised by Volta for generating electricity and usually known as the *voltaic pile*. It consists of a series of pairs of discs of zinc and copper in contact, each pair being separated by a piece of flannel or blotter moistened with brine, and arranged one on top of another. By connecting the top and bottom disc, an electric current will pass.

Galvanic Polarization.—An occasional term for the polarization of a voltaic cell.

Galvanic Taste.—A peculiar taste noticeable when two wires from a voltaic cell are touched by the tongue.

Galvanism.—A term formerly applied to current or voltaic electricity.

Galvanized Iron Wire.—Iron wire for electrical purposes must be *galvanized*, or

coated with zinc, to prevent rust. Galvanizing is not an electrical process as its name implies but consists simply of dipping the iron into melted zinc.

Galvano.—An occasional term for electro, as abbreviated from the word electrotype.

Galvano-caustic Loop.—An electric cautery consisting of a loop of platinum wire which, when brought to a white heat by an electric current, is drawn through the parts to be surgically treated.

Galvano-cautery or Caustry. — The surgical treatment of the human body such that parts are seared by the heat of a platinum wire made white hot by a current of electricity.

Galvano-faradization.—In electro-therapeutics, the simultaneous application of voltaic and faradic currents.

Galvanometer.—An instrument for indicating the presence of an electric current in a circuit, and determining its direction, strength and pressure, by measuring the electromagnetic effect of the current. Its principle is that a magnetic needle is deflected when influenced by an electromagnetic field, and a simple galvanometer consists essentially of a magnetic needle suspended within a coil of wire and free to swing over the face of a graduated dial. The action of the current was discovered by *Oersted.*

Galvanometer Constant.—The strength of the field produced at the center of a galvanometer coil by the unit of current.

Galvanometer Shunt.—A known resistance connected across the terminals of a galvanometer in parallel with the coils, for the purpose of furnishing to the instrument a current proportional to the line current in a certain ratio.

Galvanometer Switch.—A switch for a dynamo galvanometer.

Galvanometer Voltmeter.—A galvanometer designed to measure differences of potential.

Galvanometry.—The use of a galvanometer in the measurement of current strength.

Galvano-plastic Adhesion.—Adhesion between two surfaces produced by a galvano-plastic deposit.

Galvano-plastic Bath.—A name formerly given to the solution employed in the preparation of electrotype plates. It consists of an 8 to 10 per cent. solution of sulphuric acid in water, in which copper sulphate is dissolved until saturated at ordinary temperatures; an *electro-bath.*

Galvano-plastic Matrix.—A name formerly given to the mould employed in electrotyping.

Galvano-plastics.—A general term formerly applied to the deposition of metals by electrolysis, especially in electrotyping.

Galvano-plastic Soldering.—Soldering by an electrolytic deposit.

Galvanoplasty.—In a restricted sense, the term applies to the production, by the aid of electrolysis, of copies of various articles true to nature, and of such thickness as to form a resisting body which may be removed from the object serving as a mould. The term is sometimes used broadly for *electrotyping.*

Galvanoscope.—A simple type of galvanometer which serves merely to show the presence of an electric current without measuring its strength. It is an indicator of currents where the movement of the needle shows the direction of the current, and indicates whether it is a strong or a weak one. When the value of the readings has been determined by experiment or calculation any galvanoscope becomes a galvanometer.

Galvanoscopic Frog.—The hind legs of a freshly killed frog, which, when properly prepared, can serve as a delicate galvanoscope.

Galvano-therapeutics.—A name sometimes given to electro-therapeutics, the science and practice of the medical applications of electricity.

Galvanotonus.—The state of muscular contraction produced by excessive electric stimulation.

Galvanotropism.—Movements in growing organisms caused by the passing of an electric current through them.

Gamma Rays.—One of the three different types of radiation emitted from radio-active substances. Gamma rays have the following characteristics: they are not deviated by a magnetic field; they have far greater

power of penetrating matter than the alpha or beta rays; they always accompany beta rays, and, according to a recent theory they may be regarded as X-rays of a very penetrating kind.

Gantry Crane.—In machinery, an overhead traveling crane carried on trussed beams or girders; as, in the erecting department of a machine shop.

Gap Space.—1. An air gap in a magnetic circuit.

2. In ignition, a break in the secondary circuit between the points of the spark plug; the *air gap.*

Gap Wire Gauge.—A wire gauge in which gaps of various sizes are left in the rim of a metal disc into which wire may be fitted for measurement.

Gas.—That fluid form of matter which is elastic and tends to expand indefinitely. A term used at first by chemists as synonymous with air, but since restricted to fluids supposed to be permanently elastic; as, oxygen, hydrogen, etc., in distinction from vapors, as steam, which become liquid on a reduction of temperature.

Gas Battery.—A battery made up of gas cells.

Gas Burner, Electric.—A gas burner which may be lighted by an electric spark.

Gas Cell.—A voltaic cell in which platinum electrodes in contact with hydrogen and oxygen, take the place of the usual zinc and copper plates.

Gaseous.—Partaking of the nature of gas; that is, possessing no natural boundaries or form, but accommodating itself to the shape of the vessel containing it, and expanding to the dimensions of any space, no matter how great.

Gas Jet Photometer.—A photometer in which a jet of gas of given height, under certain conditions, serves as a standard of illumination.

Gasket.—1. The plaited hemp used for packing a piston; as, of a pump or the stuffing box of an engine.

2. Any ring or washer of packing.

3. A thin sheet used in making joints.

Gas Lighting, Electric.—Lighting gas jets by electricity.

Gas Lighting Torch.—A portable device for producing an electric spark for lighting gas jets.

Gasoline.—A volatile distillate from crude petroleum, largely used as a fuel in internal combustion engines. The boiling point of gasoline ranges from 120° to 250° F., with an average range between 149° and 194° F. Its vapor is 3.05 times as heavy as air, and its calorific power is between 18,000 and 20,000 B. T. U.

Gasoline is a compound of several spirits of varying density and gravity, being a volatile essence distilled from petroleum oil. When used as a fuel for internal combustion engines it should have a specific gravity of about .682, or 76°B. Some English authorities recommend spirit having a specific gravity of from .72 to .74, or between 65° and 59°B, virtually what is known in the United States as high-grade benzine. Hydrocarbon spirits of lower degrees on the Baumé scale become increasingly difficult to vaporize.

Gasoline Engine or Motor.—An internal combustion engine in which is utilized the energy contained in an air, charged in a cold state with the vapor of gasoline, the gasoline fuel being vaporized in a device called a carburetter before it enters the cylinder. The usual gasoline engines applied to automobiles are four-cycle. In stationery practice, gasoline engines are in use for driving electric generators, power pumps, etc.

Gas Pliers.—Strong pliers with curved serrated jaws by means of which a gas pipe can be held. The jaws are made to a double or treble curve to suit various sizes of pipe and a burner nipple, while one handle is formed as a screw driver and the other as a claw.

Gas Polarization.—The effect produced upon a voltaic cell by the collection of bubbles of hydrogen gas upon the copper plate.

Gas Producer.—A form of furnace charged with coke and other carbonaceous fuel through which air and steam is blown forming a mixture of hydrogen, oxygen, carbon monoxide and certain non-combustible gases, which combination is known as producer gas. This gas is an economical fuel, and after purification can be used to drive gas engines.

Gassing.—The evolving of gas from the plates of a storage battery, due to too great strength of the charging current.

Gassiot's Cascade.—A peculiar effect produced by placing a goblet, having part of its interior surface lined with tinfoil, into an air pump receiver. A wire is inserted from the top of the receiver and projected into

the glass without touching the foil. When a partial vacuum is maintained by the pump and a high tension electric current discharged between the wire and the metal of the air pump, a luminous effect is produced, as if *pale blue electricity* was overflowing the goblet.

Gastroscope, Electric.—An apparatus for illuminating the human stomach by an incandescent lamp, and permitting a medical examination by prism reflections.

Gate Valve.—A *sluice valve*; one having two inclined seats between which the valve wedges down in closing, the passage through the valve being in an uninterrupted line from one end to the other, while the valve, when opened, is drawn up into a dome or recess, thus leaving a straight passage the full diameter of the pipe.

Gas Voltmeter.—A device for measuring the strength of an electric current by determining the volume of gas evolved by the electrolysis which the current produces in a solution through which it is caused to pass.

Gauge.—A measure; a standard of measurement; an instrument to determine dimensions or capacity.

Gauge, Electric.—A name sometimes applied to any simple portable galvanometer such as those suitable for ordinary testing work.

Gauge Pressure.—The tension of a fluid as registered upon a pressure gauge, to which 14.7 lbs., or the weight of the atmosphere, must be added in order to ascertain the absolute or true pressure.

Gauss.—The unit of *intensity* of a magnetic field.

Gaussage.—The value of a magnetic flux density expressed in gausses.

Gauss, Karl Friedrich.—Born 1777, died 1855. A German mathematician; founder of the mathematical theory of electricity, and inventor of the bifilar magnetometer (1835).

Gauze Brushes.—Commutator brushes made up of copper gauze folded several times so as to form a solid flat strip, the thickness increasing with the volume of current to be collected.

Gear Clutch Arc Lamp.—An arc lamp provided with a gear clutch for regulating the feeding of the carbon into the arc.

Gearless Car Motor.—A motor which may be applied directly to the axle of a car wheel without the use of gearing to regulate the speed.

Gear Wheel.—A toothed wheel; a cog wheel.

Geissler, Heinrich.—Born 1814, died 1879. A German maker of chemical and physical apparatus; inventor of the so-called Geissler tubes (1854).

Geissler Mercurial Pump.—A form of air pump used in exhausting incandescent lamp bulbs, which produces the vacuum by the suction of mercury drawn through glass tubes.

Geissler Tubes.—Tubes of thin glass blown into a great variety of shapes, generally consisting of two bulbs joined by a slender spiral or twisted tube. They are provided with platinum electrodes which are fused into the glass after a partial vacuum has been formed by an air pump, so that by the passage of an electric discharge through them under different conditions a great variety of luminous phenomena may be observed. The color of the light depends upon the kind of glass and upon the gas enclosed. Geissler tubes are sometimes made in beautiful designs. The incandescent lamp is the most common form of the Geissler tube.

Gem Lamp.—A name sometimes given to the "metalized" or "graphitized" filament incandescent lamp.

General Faradization.—In electro-therapeutics, the application of faradic currents in such a degree as to affect the entire body.

General Galvanization.—In electro-therapeutics, the application of the electric current to such an extent as to affect the entire body.

General Manager.—The administrative head of a corporation or large firm; the chief executive employe, whose duty it is to initiate and maintain policies and the broad lines of administration. The general manager has charge of all the departments.

Generate.—To produce, especially by a vital or chemical process; as, the generation of electricity.

Generating Station.—In an electric system, the power plant or central station containing the engines, boilers, dynamos, etc., for generating electric power.

Generating Surface.—1. In steam engineering, the entire superficies of a steam boiler exposed to the flame and incandescent gases on the one side, and to the water upon the other. Usually called *heating surface.*

2. In smelting and founding, the total area of the brick partition in regenerative furnaces, etc.

Generator.—A general name given to a machine for the transformation of mechanical into electrical energy. The expression *dynamo,* is used to denote any electric generator, with the exception of the *magneto.* To distinguish the different types, the terms *d. c. generator, a. c. generator* or *alternator, motor generator set,* etc., are applied.

Generator Ammeter.—An ammeter for measuring the current delivered by a dynamo.

Generator Bus Bars.—The bus bars which receive the current from the entire group of dynamos in a central lighting or power station.

Generator Panels of Switchboard.—The panels of the switchboard in a central lighting or power station to which the bus bars are connected and upon which the voltmeters, ammeters and switches are mounted.

Generator Switch.—A switch by which a dynamo may be connected with, or disconnected from, the bus bars.

Generator Unit.—One of a group of dynamos in a central station.

Generator Voltmeter.—A voltmeter for measuring the electric pressure of a dynamo.

Geomantic Lines of Force.—The lines of force of the earth's magnetism.

German Candle.—A standard of photometric measurement employed in Germany. It is a paraffin candle burning with a flame of 50 millimeters (1.98 inches) height.

Germanium.—A metal of gray white color and fine metallic luster. It melts at 1562° F.

German Silver.—An alloy having comparatively low conductivity, composed of copper, zinc and nickel in varying proportions, used in making resistance coils; sometimes called nickel silver. It consists of an alloy of copper two parts, nickel one part, and zinc one part. The variation of its resistance with change of temperature is very small.

Gilb.—An abbreviation for the *gilbert.*

Gilbert.—The practical unit of magnetomotive force, equivalent to the magnetomotive force of 0.7958 ampere turn.

Gilbert, William.—Born 1540, died 1603. An English physicist, noted for his experiments in magnetism, and for the publication in 1600 of his chief work "De Magnete" which marked an epoch in the science of magnetism, and earned for its author the title of the "founder of the science of magnetism and electricity." His work led to further study by other philosophers who discovered other electric and magnetic truths. Gilbert disposed of a number of false ideas connected with electric and magnetic phenomena. He made valuable investigations on the nature and properties of magnetic poles and showed that many other substances besides amber become electrified by rubbing.

Gilder's Wax.—A fatty, solid substance which is used by gilders to cover those parts of an object which are not intended to be gilded.

Gilding.—Depositing a layer of gold by electroplating, or overlaying with gold leaf or powder by hand.

Gilding, Electric.—Depositing a layer of gold by electroplating. The electric current passing from a plate of pure gold through a bath of cyanide of gold in which the articles to be plated are suspended.

Gilt Plumbago.—Powdered graphite which has been electro-gilded to increase its conducting power, so that it may be used to advantage in dusting the surfaces of wax or paper pulp moulds in electrotyping, to render them conducting for the deposition of copper.

Gimbals.—A method of suspension for securing free motion to a compass or chronometer on shipboard, so that it shall always preserve a horizontal position. Gimbals usually consist of a pair of rings moving on pivots in such a way as to have free motion in two directions at right angles, so as to neutralize the motion of the vessel.

Gimlet.—In wiring, a screw pointed tool used for boring holes in wood.

Gin Pole.—[From gin, a contraction of *engine.*] A contrivance for raising or moving heavy weights, consisting of a strong pole with four ropes fastened at the top end to guide it, and also a block and fall fastened on the top of the pole. Generally a small cross piece, about 8 or 10 inches down from the top, is nailed on to hold guide lines and hoisting tackle.

Girder.—1. In building, a principal beam, spanning from wall to wall of a building, affording support for the binding joists, to which floor and ceiling joists are connected.

2. In engineering, a beam of iron or steel, either cast or rolled as one piece, or else built up out of plates and sections of mild steel. The latter method is the more usual and is what is generally understood by the term.

3. In carpentry, a flitch beam, or one of several planks secured together, side by side.

Girder Armature.—An early form of Siemen's armature having a core resembling the letter H.

Girder Sections.—Rolled joists and girders of H or I form or similar sections, for use as girders.

Girder Stays.—In boiler setting, the stays of girder form supporting the crown of a combustion chamber.

Girth.—The circumference of anything.

Girth Seams.—The seams which pass around the body of the boiler, commonly known as circumferential seams.

Gland.—The sliding bushing which holds the packing in a stuffing box; it is usually adjusted by bolts and nuts. Sometimes called a *follower.*

Glass.—A hard, brittle, usually transparent substance made by melting together sand or silica with lime, potash, soda or lead oxide. Different qualities of glass such as flint, crown, plate or bottle are made by varying the proportions.

Glass Fuse.—A fuse enclosed within a glass tube.

Glass Insulator.—A line wire insulator made of glass. A glass insulator is cheaper than porcelain, and owing to its transparency can be more easily examined, but glass is less strong both mechanically and electrically, and more apt to collect a film of moisture, and so for high tension transmission, porcelain is almost exclusively employed.

Glass Screw Insulator.—A glass insulator for overhead wiring, designed to screw down upon wooden pins; the ordinary line wire insulator.

Glaze.—A gloss or smooth transparent surface applied to porcelain, as in the manufacture of insulators for high tension circuits. It is generally composed of an admixture of alkalies with silica, lime, and often oxide or carbonate of lead.

Globe Holder for Arc Lamp.—A support for an arc lamp globe.

Globe Net for Arc Lamp.—Wire netting surrounding the globe of an arc lamp.

Globe Strain Insulator.—A form of insulator employed in strain, or pull-over wires in a trolley line, consisting of a pair of interlocking rings which are kept insulated from each other by means of an insulating ball or globe in which they are embedded; a spherical strain insulator.

Globular Lighting.—A very rare form of lighting appearing as a ball of fire which at first floats silently in the air and then bursts with a loud explosion.

Globular Spark.—A discharge resembling globular lighting sometimes produced by an electrical apparatus.

Gloves.—In electric repair work, rubber gloves are used to prevent the frequent and often fatal accidents occurring to linemen from shock while handling electric light wires or other wires in contact with the same, and also the dangers of line work from lightning in stormy weather. Gloves are also useful in handling the acids of batteries.

Glow.—White or red heat; to give forth vivid light and heat.

Glow Discharge.—A variety of convective discharge seen at the tip of a pointed conductor.

Glower.—In the Nernst lamp, the pencil of refractory oxides which becomes incandescent upon the passage of the electric current.

Glow Illumination.—1. Light unaccompanied by heat, as the glow of a fire fly.
2. Incandescent lighting.

Glowing of Electric Conductor.—The radiation of light from a conductor due to intense electrical heating.

Glow Lamp.—An incandescent lamp.

Glucinum.—A rare metallic element of a white color, resembling magnesium in its properties.

Glue.—Gelatine in an impure form obtained from animal refuse such as skin, bones, etc. The best quality of glue is insoluble in cold water, but absorbs a quantity when immersed. The various processes of making glue consist of digesting hides or bones, clarifying the gelatinous liquor and running it into moulds.

Glue Pot, Electric.—A glue pot provided with an electrical heating arrangement.

Glyphography.—An electrotype process by which a copy of an engraved plate is obtained in a relief, so that it may be used in letter press printing.

G. M. B.—An abbreviation for the English term: Good merchantable brands. The fair average quality of copper ingots as quoted in the metal market, etc.

G. M. D.—Abbreviation for geometrical mean distance.

G. M. T.—Abbreviation for Greenwich mean time.

Gneiss.—A crystalline or igneous rock, consisting, like granite, of quartz, feldspar and mica, but having these materials, especially the mica, arranged in planes, so that it breaks rather easily into coarse slabs or flags.

Gnomon, Electric.—A name sometimes given to a type of pith ball electroscope.

Go Devil.—1. The squib or detonator which is dropped down a drilled well to explode the nitroglycerin used to "shoot" it.
2. A scraper with self adjusting spring blades, inserted in a pipe line, and carried forward by the fluid pressure, clearing away accumulations in the walls of the pipe.

Gold.—A conductor of electricity, noted for its beautiful yellow color, ductility, malleability, and freedom from liability to rust or tarnish. Its specific gravity is 19.3 and melting point 2000° F.

Gold Bath.—A solution of cyanide of gold in which articles are suspended for electroplating with gold, or electro-gilding.

Gold Leaf Electroscope.—An electroscope which determines the presence and kind of an electric charge by the action of two strips of gold foil suspended from a brass rod in a glass jar.

Gold Plating.—Depositing a layer of gold by electroplating; gilding.

Gong Signaling.—Railroad electric signals in which gongs are sounded according to a *code.*

Goose Neck Pull Off.—In electric traction, a "goose neck" curve insulator, either single or double, to which the strain wires are attached to keep a trolley wire in place along a curve.

Gordon Cell.—A non-polarizing closed circuit cell used largely for fire, police and railway signal systems. The negative element consists of a perforated tin cylinder containing the depolarizer. The zinc element rests on porcelain lugs in an electrolyte of caustic soda solution.

Gould Storage Battery.—A make of battery largely used in America. It is of the Planté type, and its distinguishing feature is the method of increasing the active surface of the plates. The plates are "spun", the solid lead plate being run between a number of small, sharp edged rollers which cut deeply into the lead causing the displaced lead to rise up between the rollers thereby thickening the plates and forming a series of fine ribs.

Governor.—A device or attachment for controlling and regulating the speed of a prime mover, usually by means of centrifugal force or by pressure. In a steam engine, the principle of the conical pendulum is generally employed, as the speed of the engine increases the centrifugal force causes the weights to fly out, thus shortening the height of the pendulum; this shortening pull being transmitted to the throttle valve or valve gearing of the engine. A governor of the same type controls the admission of water to water wheels, turbines, etc.

Governor, Electric.—Any electric speed controlling or movement regulating device.

G. P.—Abbreviation for gutta percha.

Gradient, Electric.—The rate of increase or decrease of a variable magnitude, sometimes used for the curve that represents a variable current.

Gradometer.—A variety of clinometer, consisting of a curved glass vial filled with alcohol and a graduated scale. The position of the bubble shows the degree of the gradient.

Gram or Gramme.—The unit of mass, or amount of matter, in the C. G. S. system; it is the one-thousandth part of the mass of a standard kept in Paris called the kilogram. For practical purposes the gram is equal to the mass of one cubic centimeter of water at 4° C., or 15.43235 grains.

Gram Atom.—In chemistry, the amount of an elementary substance having a weight in grams equal in number to the atomic weight of the element.

Gram Calorie.—A unit of heat, representing the amount of heat required to raise the temperature of a gram of water 1° Centigrade.

Gram Equivalent.—The quantity of a substance in grams equal numerically to its electro-chemical equivalent.

Gramme Armature.—A form of ring armature invented by Gramme, in which the armature core, consisting of a ring of iron wire, is wound uniformly with insulated copper wire, which is, at equal intervals, electrically connected to the segments of the commutator.

Gramme Winding.—The form of winding employed upon a Gramme ring armature. The core of the armature being in the form of a ring, the wire is wound through the core as well as upon the outside. This type of winding is now used only in arc light dynamos and small motors. Also called ring winding.

Gramme, Zenobe Theophile.—Born 1826; died 1901. A French electrician, inventor of a successful ring armature (1869), and the first alternating current dynamo.

Gram Molecule.—In chemistry, the amount of a compound having a weight in grams equal in number to the molecular weight of the compound.

Granite.—A crystalline, unstratified rock, consisting of quartz, feldspar and mica, and presenting usually a whitish, grayish, or flesh red color. It differs from gneiss in not having the mica in planes. Granite is regarded as a true igneous or fire rock.

Granular Carbon.—The carbon grains employed at varying resistance between the electrodes of a telephone transmitter. The best grade is made from very hard and pure anthracite which has been carefully carbonized and afterwards crushed and screened. The grains are dense, jet black, brilliant in luster and extremely hard.

Granular Carbon Transmitter.—A telephone transmitter in which carbon grains are employed as varying resistance between the electrodes; a *dust transmitter.*

Granular Coherer.—A form of wave detector for wireless telegraphy experimented with in the early development of the science. It consisted of a glass tube containing carbon granules between metallic electrodes.

Granular Microphone.—A telephone transmitter employing granular carbon to furnish the varying resistance between the electrodes.

Granular Telephone.—A telephone provided with a dust, or granular carbon transmitter.

Graphic Method.—The system or method of solving problems in the equalization or distribution of forces, stresses, loads, etc., by means of accurately drawn figures and diagrams.

Graphite.—One of the three forms in which carbon occurs in nature; also called plumbago and black lead. It has an iron gray color and a metallic luster. It is used in the manufacture of pencils and crucibles and as a lubricant. Regarding its use as a lubricant, Rennie in 1829 says: "Graphite lessened friction in all cases where it was used." General Morin, at a later date, concluded from experiments that it could be used with advantage under heavy pressures; and Prof. Thurston found it well adapted for use under both light and heavy pressures when mixed with certain oils. It is valuable to prevent abrasion and cutting under heavy loads and at low velocities.

Graphite Coating.—A layer of powdered graphite sometimes distributed over a non-conducting surface in order to render the surface a conductor of electricity, especially

in electrotyping when a mould requires a surface of metal for printing purposes.

Graphitized Filament Lamp.—A term sometimes applied to the *metallized* filament incandescent lamp, in which the carbon thread has been subjected to excessive heat in a form of electric furnace so that the texture of the filament has more of the characteristics of a metal than of carbon.

Grapnel.—An implement having flukes or prongs for grappling purposes; a grappling iron for seizing a submarine cable or other object under water.

Grapnel Toes.—The flukes or claws of a grapnel.

Grappling.—Exploring the bed of the sea or other bodies of water for sunken objects with the aid of a grapnel.

Grate Surface.—In steam boilers, the amount of grate surface required per horse power, varies to a considerable degree, depending upon the amount of draught and kind of coal used. In designing a boiler for a given set of conditions, the grate surface should be made as liberal as possible; say, sufficient for a rate of combustion of ten lbs. per square foot for anthracite, and fifteen lbs. for bituminous coal.

Gratings.—A plate, usually of glass, ruled with fine lines forming alternate opaque and transparent parallels for producing spectra of light by diffraction

Gravity.—A force which gives to every particle of matter a tendency toward every other particle. This influence is conveyed from one body to another without any perceptible interval of time. The weight of the body is the force it exerts in consequence of its gravity, and is measured by its mechanical effects. We weigh a body by ascertaining the force required to hold it back, or to keep it from descending. Hence, weights are nothing more than measures of the force of gravity in different bodies.

In the case of falling bodies, the acceleration due to gravity is 32.16 feet per second in one second; this is indicated by the symbol g. The value of g increases with the latitude and decreases with the elevation. At the latitude of Philadelphia 40°, its value is 32.16. At Paris 48° 50′ N., $g = 980.87$ cm = 32.181 ft. For all ordinary calculations for the United States, g is generally taken at 32.16.

Gravity Ammeter.—An ammeter in which the index needle is held at zero by the force of gravity, and is drawn away against that force by the action of the current to be measured.

Gravity Annunciator Drop.—An annunciator drop which, when released, falls by the force of gravity.

Gravity Cell.—A two fluid primary cell in which the electrolytes are kept separate by the difference in their specific gravity, the denser liquid resting at the bottom of the jar while the lighter solution stays on top; the "bluestone" cell.

Gravity Drop Annunciator.—An annunciator provided with gravity drops.

Gravity Feed Arc Lamp.—An arc lamp in which the mechanism for preserving the arc lets the upper carbon drop under the influence of the force of gravity.

Gravity Needle Drop.—A needle annunciator having a gravity drop.

Gravity Voltmeter.—A variety of voltmeter in which the potential difference to be measured deflects the index needle against the action of gravity upon a weight.

Gray, Elisha.—Born 1835, died 1901. An American electrician; inventor of a self-adjusting telegraph relay (1867), a telegraph repeater, a printing telegraph, the telautograph (1890), and other apparatus chiefly concerned with the telegraph and telephone. He disputed with Bell the credit for the invention of the telephone (1876).

Gray Iron.—There are many varieties of cast iron, differing from each other by almost insensible shades. The two principal divisions are gray and white, so called from the color of the fracture when recent. Gray iron is softer and less brittle than white iron. It is to a slight degree malleable and flexible, can be easily drilled and turned in the lathe, and does not resist the file. It has a brilliant fracture, of a gray, or sometimes a bluish gray color; the color is lighter as the grain becomes closer, and its hardness increases at the same time.

Grease Spot Photometer.—A familiar name for *Bunsen's photometer* which consists essentially of a paper screen with a grease spot in the center, on either side of which are placed the two lights to be compared. When the screen is equally illuminated on both sides the spot becomes invisible.

Greater Calorie.—A unit of heat in the C. G. S. system larger than the calorie; it is the amount of heat necessary to raise the temperature of a kilogram of water from 0° to 1° Centigrade.

Greek Alphabet.—The letters of the Greek alphabet are used as arbitrary signs, and the letter π (pi) is used almost universally to represent the ratio of the circumference to the diameter of the circle. Some of the Greek letters are used as electrical symbols.

Α	α	alpha	Ι	ι	iota	Ρ	ρ	rho
Β	β	beta	Κ	κ	kappa	Σ	σ	sigma
Γ	γ	gamma	Λ	λ	lambda	Τ	τ	tau
Δ	δ	delta	Μ	μ	mu	Υ	υ	upsilon
Ε	ε	epsilon	Ν	ν	nu	Φ	φ	phi
Ζ	ζ	zeta	Ξ	ξ	xi	Χ	χ	chi
Η	η	eta	Ο	ο	omicron	Ψ	ψ	psi
Θ	θ	theta	Π	π	pi	Ω	ω	omega

Green Candle.—A standard candle having a green glass screen for the purpose of measuring the candle power of an arc lamp.

Grenet Cell.—A variety of bichromate primary cell. A zinc plate is suspended between two carbon plates without touching them, and so adjusted that it may be withdrawn from the solution when the cell is on open circuit.

Grid.—1. A lead plate for a storage cell; it is provided with corrugations or perforations so that it may be capable of holding a large amount of the active material, and thus increase the capacity of the cell.

2. In wireless telegraphy, an arrangement of several parallel aerial wires.

Grid Plugs.—In storage battery practice, plugs of oxide of lead inserted into the perforations of a grid to assist in the *forming* process.

Grill Work.—In engineering, a heavy framework of cross timbering, resting upon the heads of piles, serving as a foundation for a building resting on insecure or treacherous soil.

Grip Controller.—A device applied to motor cycles operated from the grip, or handle, which controls the motor by interrupting the ignition.

Grip of Belt.—The hold which a driving belt has upon the pulley.

Grommet or Grummet.—In engineering, a ring formed of a strand of rope, laid round by others in a particular manner; a ring of a soft yarn strand wound around or served by its own part, used to stop leaks under bolt heads.

Grotthuss, Theodor.—(Properly, Christian Johann Dietrich.) Born 1785, died 1822. A German physicist, distinguished for formulating (1805) the theory of electrolysis which bears his name.

Grotthuss' Theory.—A theory advanced to explain the process of electrolysis which takes place in a voltaic cell, suggesting that the molecules of the liquid arrange themselves in chains, the particles being alternately charged positively and negatively, and that along these chains the decompositions and recombinations occur.

According to the theory all the molecules arrange themselves in regular order with their unlike "poles" or ends in contact. The new arrangement is due to the fact that each one is "polarised," or has acquired magnetic qualities. In addition to this "polarisation," all the molecules are supposed to move in regular order, in lines, from the zinc electrode to the copper, and back again. In course of this "rotation," or traveling around, it is found that the sulphur and oxygen unite with the zinc, causing it to waste, and the hydrogen, thus liberated, unites with the oxygen of the molecule just ahead; that, in turn, giving its oxygen to the molecule in front of it, and so on, until the copper electrode is reached. The hydrogen is given off to unite again with the liquid and perform the same rotation, until all the oxygen has united with and consumed the zinc plate.

Ground.—The earth regarded as an electric conductor.

Ground Circuit.—An electric circuit which is completed by the use of the ground as a part of the circuit; *an earth circuit.*

Ground Coil.—A small rheostat used in duplex telegraphy for preserving the balance of the line at the home station.

Ground Detector.—It is important to know when any portion of an electric circuit becomes accidentally connected with the ground, and for this purpose a group of lamps or voltmeters is provided at a central station, indication of a "ground" being given by the lighting of the lamps or the movement of the voltmeter needle.

Grounded Circuit.—An electric circuit completed through the ground.

Grounded Dynamo.—A dynamo connected to ground.

Ground Incandescent Switch.—A switch which controls a group or cluster of incandescent lamps.

Ground Indicator.—A device for indicating any defect in the insulation of a telegraph or telephone line.

Grounding.—The leaking of an electric current into the ground; or the intentional connection of a circuit to the earth.

Ground Line.—The ordinary level of the surface of the ground, above or below which the height of structures or the depth of excavations is measured.

Ground Plate.—A metal plate buried in damp soil forming a path to earth in a grounded electric circuit; *an earth plate.*

Ground Return.—The earth or ground used to complete an electric circuit.

Ground Wire.—The conductor which makes the connection with the ground in a ground circuit.

Grouting.—In construction work, the pouring of a mixture of cement, sand and water into *the voids* of stone, brick or concrete work, either to give a solid bearing or to fasten anchor bolts, dowels, etc.

Grove's Cell.—A form of primary cell consisting of an outer jar containing a zinc electrode in dilute sulphuric acid, and an inner porous cup with a platinum electrode in strong nitric acid.

Grove's Gas Battery.—An early form of storage battery devised by Sir W. R. Grove in 1829. Plates of platinum are contained in glass tubes closed at the top, the lower ends being immersed in dilute sulphuric acid. The charging current introduces oxygen into certain of the tubes and hydrogen into others. The platinum in contact with these gases then permits of a current to be derived from the cell equal, under favorable circumstances, to 843 volts per couple.

Grove, Sir William Robert.—Born 1811, died 1896. An English physicist, inventor of the type of voltaic cell known as Grove's cell (1839), and the earliest type of incandescent lamp (1840).

Growth of Lines of Force.—The extending and expanding of lines of force.

Guard Arm.—In pole line construction, an upright attached to a cross arm to prevent a wire from falling in case it becomes detached from its insulator.

Guard Suspension Wire.—A span wire stretched above a trolley wire from the tops of opposite poles in order to support the *guard wires.*

Guard Wire.—A wire stretched parallel to a trolley wire and just above it to prevent other wires from falling across and making electrical contact with the live wire; *a running guard wire.*

Guard Wire Hanger.—A hanger for supporting a guard wire.

Guide Passages.—In hydraulics, passages which direct the water upon the blades of a turbine, the enclosing partitions being movable to vary the width of the flow, etc.

Gun Metal.—A bronze, ordinarily composed of nine parts of copper and one of tin. The name is also given to certain strong mixtures of cast iron.

Gunpowder.—An explosive, compounded of 75 per cent. saltpetre, 15 per cent. charcoal, and 10 per cent. sulphur. The temperature of explosion is about 2000° C., and the volume of gas evolved is 300 times that of powder. When the ratio of volume of powder, to the capacity of the containing space is one, the pressure of explosion is about 42 tons per square inch.

Gunter's Chain.—Consists of one hundred links, each link being seven inches and ninety-two one-hundredths in length; making up the total length of four rods, or sixty-six feet; hence, a measure of that length. An acre contains ten square *chains.*

Gutta Percha.—A substance obtained from the gum of a tropical tree found in the East Indies. It has many of the properties of india rubber and is of great value in electrical work for its insulating powers and durability.

Gutter of Insulator.—A depression in an insulator to lead off rain water.

Guy.—A rod, wire or other appliance for stiffening a telegraph pole, or for steadying a system of overhead wires.

Guying.—Steadying anything by the use of guys.

Guy Rod.—A rod of galvanized wrought iron or of steel, employed as a guy to stiffen a telegraph pole; *a stay rod.*

Guy Rod Bands.—Bands by which a guy rod is attached to a telegraph pole.

Guy Rope.—A rope serving as a guy.

Guy Stubs.—A stub driven into the ground for the purpose of anchoring a guy.

Guy Wire.—A wire serving as a guy.

Gymnotus Electricus.—The scientific name for the *electric eel*.

Gyration.—The act of revolving about an axis; *rotation.*

Gyroscope.—An instrument used to illustrate the dynamics of rotating bodies, consisting essentially of a fly wheel, mounted in a ring, with its axis free to turn in any direction.

Gyroscopo, Electric.—A gyroscope driven by an electric motor.

Gyrostat.—An instrument for illustrating the dynamics of rotation.

Gyrostatic Action of Dynamo.—The effect produced by the motion of the vessel upon the rotation of the parts of a dynamo operated on shipboard

H.—1. The symbol for the intensity of a magnetic field; its unit is the *gauss*.
2. The symbol of induction. The *Henry*.
3. The symbol for the horizontal intensity of the earth's magnetism.
4. An abbreviation for hydrogen.

h.—1. An abbreviation for the *henry*, the practical unit of induction.
2. Abbreviation for *hour*.

Hæmatite.—Ferric oxide. An important ore of iron, occurring in steel blue or black crystals, or blood red when very thin, also in blood red masses, whence the name *bloodstone* by which it is often known. It is found in the Marquette region of Lake Superior in the U. S. Hæmatite is also known as *specular iron*.

Half Crossed Belting.—In millwrighting, belting is half crossed when it drives between two pulleys whose axes are at right angles with each other. Half crossed belting can run only in one direction.

Half Deflection Method.—A method of electrical measurement in which the galvanometer deflection is reduced one-half.

Half Gate.—The state of a hydraulic turbine in operation with the gate open only half-way, as in hydro-electric plants running with light loads.

Half Hoop Magnet.—A semi-circular magnet.

Half Load Efficiency.—The efficiency of an electric machine when operating at half its capacity.

Half Shade for Incandescent Lamp.—A shade that envelops a lamp bulb only half way.

Half Wire Guard for Incandescent Lamp.—A wire guard for protecting only one half of an incandescent lamp.

Hall, Edwin Herbert.—Born 1855. An American physicist. His chief investigations have been in connection with the so called Hall effect in various metals; changes of temperature in walls of the steam engine cylinder; thermal conductivity of nickel and iron; deflection of falling bodies; theory of thermo-electric action, etc.

Hall Effect.—A phenomenon first observed by E. H. Hall in 1879, of a transverse electromotive force produced when a powerful magnet is caused to act upon a current flowing in a strip of very thin metal. Assume a steady current to flow through this thin metal strip, and let two points, transversal to the line of flow, be connected to a galvanometer. These points of contact can be adjusted until there is no deflection, showing that they are in the same equipotential line. If the strip of metal be placed in a strong magnetic field at right angles to the lines of force, a deflection of the galvanometer is produced, which indicates that an alternation takes place on the stream lines of current in the strip. The effect is said to be due to the deflections of the moving carriers of the current or *electrons*.

Halleyan Lines.—Lines drawn upon a map passing through points on the earth's surface which have the same magnetic declination; the isogonic or isogonal lines.

Halpine-Savage Torpedo.—A submarine torpedo operated by electricity, and propelled by a current generated within itself.

Hammer Break.—1. In internal combustion motors, a make and break ignition through an exceedingly rapid separation of the sparking contacts, by striking the movable contact a blow with the igniter hammer, the latter being operated by a strong spring.
2 In jump spark ignition, a rapid separation of the contact points of a magnetic vibrator produced with a compound mechanism, consisting of two vibrator blades. One blade, attracted by the action of the coil, is set in motion and delivers a "hammer blow" to the second blade, which contains the movable contact. The action produces a rapid interruption of the primary current.

Hammer Test.—A trial of the qualities of sheet metal, such as iron, copper or steel, by the use of the hammer; such as flattening out cold to a thickness of one-half the diameter, and flattening out hot to a thick-

ness of one-third the diameter. In neither test should they show cracks or flaws.

Hand Hole.—1. An opening large enough to readily admit the hand, provided in an underground conduit for the purpose of gaining access to the cable.

2. In a steam boiler, a small opening in the outer firebox or shell, large enough to admit the hand and arm; it is closed with a small oval door, jointed on the inside, and held in position by a dog and bolt, similar to the larger manhole of a boiler.

Hand Lighting Electric Burner.—An ordinary electric burner lighted and extinguished by hand.

Hand Operated Alarm.—An electric alarm turned in by hand as distinguished from an automatic alarm.

Hand Rail.—A protection or guard rail around machinery, etc.

Hand Regulation.—The regulation of a dynamo by hand, for preserving constant the current strength and potential difference, as distinguished from automatic regulation.

Hand Regulator.—A hand regulated resistance box, in which the separate resistance coils may be cut in or out by turning a hand wheel or switch.

Hand Rule.—A rule for determining the relation in direction between the magnetism, the motion and the induced E. M. F. in an electromagnetic circuit, generally known as Fleming's hand rule. It may be stated as follows: Let the forefinger of the right hand point in the direction of the magnetic lines; then turn the thumb in the direction of the motion; the middle finger bent at right angles to both thumb and forefinger will show the direction of the induced E. M. F.

Hand Scratch Brush.—A scratch brush for cleansing by hand the surfaces of metal objects to be electroplated.

Hand Signaling.—Sending telegraphic messages by hand in distinction from signaling by machine, or automatic signaling.

Hand Sketch.—In drawing, a rough kind of free hand drawing made without rule or compass, and although not to scale is a working drawing, because it gives all dimensions and particulars required from which to work.

Hand Telephone.—The ordinary form of telephone receiver, as distinguished from the head gear receiver.

Hand Tools.—All tools and implements, cutting or otherwise, which are used by the hand alone, to distinguish them from machine tools.

Hanger.—A metal bracket or stirrup, of various shapes, used to support electric motors when fastened to the wall, etc. The hanger depends or hangs downward from a beam or the like, hence its name.

Hanger Board.—A board provided with terminals and a switch, so that an arc lamp can readily be introduced into a circuit, or removed from it.

Hanger Cut Out.—A cut out switch provided for an arc lamp in connection with a hanger board.

Hard Brass.—1. Brass which has not been annealed after drawing or rolling. It is highly elastic and is therefore used for springs and work of similar character.

2. Hammered brass, also brass which contains a large proportion of tin.

Hard Drawn Copper Wire.—Copper wire suitable for overhead conductors having received the requisite hardness and mechanical strength by being repeatedly drawn without being annealed.

Hardening.—1. Increasing the hardness of metals either by suddenly cooling them after intense heat, or by subjecting them to hydraulic pressure while cooling slowly.

2. The preliminary process of tempering edge tools; the tool, being heated to a cherry red, is plunged into brine or clear water, the sudden quenching rendering it hard enough to scratch glass. Subsequent reheating, to a point determined by experience and judgment, is necessary to *draw the temper*, so that the steel shall have those qualities of hardness and toughness necessary for its desired duties.

Hard Iron.—Cast iron which is dense and close grained. It is obtained by making suitable mixings of various brands with scrap, and is used for wearing parts, the liners of engine cylinders, and cog wheels.

Hard Patch.—A piece of metal attached to a boiler shell, used to strengthen a weak place or cover a hole, is called a *patch*. If bolted or studded it is called a *soft patch*, if riveted, a *hard patch*.

Hard Porous Cell.—An unglazed earthenware jar made especially dense by hard baking to better resist the disintegrating action of the voltaic cell for which it is designed.

Hard Rubber.—A name often given to *vulcanite* or *ebonite* which is india rubber "vulcanized" by a large admixture of sulphur. It is much used in the manufacture of electrical instruments.

Hard Solder.—A solder which fuses only at a red heat; as one composed of zinc and copper, or silver and copper.

Hard Steel.—A loose and indefinite term, meaning all steel that is not *mild*, it may be taken as steel containing over ½ of 1 per cent. of carbon.

Hard Water.—A water in which soap will not readily dissolve, thus rendering the formation of lather difficult. Hardness may be temporary or permanent, and is due to the presence of salts, principally of lime, in solution.

H-armature.—An early form of Siemen's armature having a core resembling the letter H; a girder or shuttle armature.

Harmonic Analyzer.—An analyzer capable of being tuned to a certain note, for example, Gray's harmonic telegraph analyzer is an electromagnet whose armature, consisting of a steel ribbon, is attached to a metallic frame and tuned to proper tension by a thumb screw.

Harmonic Current.—An alternating electric current the waves of which follow the law of a simple harmonic or sine curve.

Harmonic Electromotive Forces.—Electromotive forces having periodic alternations in multiple.

Harmonic Motion.—Simple harmonic motion is the projection on a straight line of uniform circular motion. It is like that of a point in a vibrating string, and is approximately the same as the vibration of a sounding body, whence the name.

Harmonic Receiver.—In harmonic telegraphy, a receiver consisting of an electromagnetic reed tuned to vibrate to one note only.

Harmonics.—The separate overtones which go to make up a complex tone.

Harmonics of Current.—The separate harmonic currents which go to make up a complex harmonic current.

Harmonics of Sound Waves.—The separate overtones which combine to make up a sound wave.

Harness.—The equipment for adjusting the transmitter and receiver upon the breast and head of a telephone exchange operator.

Harpoon, Electric.—A harpoon provided with an electric bomb which the harpooner explodes after the weapon has reached its victim.

Harveyising.—A process, invented by R. A. Harvey, of hardening the surface of a steel plate, in which the steel is given a thick face of great hardness backed by the metal in a gradually decreasing state of hardness through its mass.

H. B. Curves.—Characteristic curves which show the ratio of the magnetic induction B, to the magnetizing force H.

Head Bath, Electric.—A convective electric discharge applied in the medical treatment of the head.

Head Board of Dynamo.—A board containing the switches or terminals of a dynamo.

Head Board of Motor.—A switchboard for use in starting a motor.

Head Gate.—In hydraulics, vertical sliding doors, to admit or shut off the water supply from the reservoir or intake to the flume, conveying it to a turbine or water wheel.

Head Gear Telephone.—A telephone watch case receiver for use in exchanges, adjustable to and fitting over the head of the operator so as to give entire freedom to the hands; a head telephone.

Head Guy.—A guy fastened to the top of a telegraph pole.

Head Guying.—1. A method of steadying telegraph poles against lateral vibrations by guying the top of one to the foot of the next on each side.

2. Attaching a guy to the top of a pole.

Head Lamp.—An electric lamp suitable to be worn upon the head.

Headlight, Electric.—On a locomotive, a powerful arc light with parabolic reflection; usually operated by a rotary steam engine direct connected to a generator, and all mounted in a compact form on one base.

Head of Liquid.—The height of water or other liquid above a given level considered in relation to the force of its fall and to the pressure per square inch at the given level.

Head of Water.—The height of the water above the orifice, at which it issues, expressed either in feet, or pounds per square inch pressure corresponding to the head. In questions relating to pressure due to head, there are two important distinctions, viz.: *static* head and *dynamic* head.

Head Race.—In hydraulics, the water course leading to the upper part of a water wheel.

Head Telephone.—A watch case receiver adjustable to the head of a telephone operator, so that the hands shall be free for making connections upon the switchboard; a head gear telephone.

Heat.—That form of energy which consists in the agitation of the molecules of matter by which heat is produced; the state of a substance in which it produces the sensation of heat.

Heat is distinguished as *sensible* and *latent*. Sensible heat or heat that may be distinguished by the touch. Latent heat means heat which has disappeared in producing a change in the *state* of a substance without changing its temperature. The Fahrenheit thermometer is generally used in measuring heat in English speaking countries, and the Centigrade or Celsius thermometer in countries which use the metric system. The graduations are as follows.

Thermometer	Freezing (degrees)	Boiling (degrees)
Fahrenheit.......	32	212
Centigrade.......	0	100
Réaumur.........	0	80

The Réaumur thermometer is used to some extent on the continent of Europe.

Heat Alarm.—A fire alarm which gives a signal when the heat becomes excessive. A thermostat may operate to close an electric circuit that rings a bell, or the circuit may be closed by the expansion of a column of mercury.

Heat Cell.—A primary cell in which an electric current is set up by the action of heat.

Heat Coil.—A protective device for telephone apparatus by means of which "sneak" currents are arrested by cutting an instrument out of circuit when a stray current exceeds a predetermined limit; *a thermal arrester.*

Heat, Electric.—The heat produced in a conductor by the passage of an electric current through it.

Heater, Electric.—A form of heating apparatus used especially in electric cars; it consists of a group of resistance coils embedded in insulating material, producing heat by the resistance offered to the passage of an electric current.

Heating by Electricity.—Electric heating, though too costly for general purposes, may be economically employed in cooking, welding in the electric furnace, for warming cars in electric railways, and in a number of minor situations. The advantages of electric heating are freedom from odor, dust, noise and fumes, ease of installation and operation, portability, safety, economy of space, etc. Two of the most important commercial uses of electric heat are in the reduction of substances in the electric furnace, and in the uniting of metal in welding. The heat of the electric arc has also been used in cutting structural steel and sheet piling with great saving of time.

Heating Effects of Current.—The effects of heat produced in a circuit by the passage of the electric current.

Heating of Dynamos.—The excessive heating of the constituent parts of a dynamo is probably the most common and at the same time the most annoying fault which arises in the working of the dynamo. It may be due to various causes, electrical or mechanical; and may occur in any one or more of the component parts of the dynamo: (1) Connections. (2) Armature, commutator, brushes. (3) Field magnets. (4) Bearings.

It may be detected by applying the hand to the different portions of the machine if low tension, or a thermometer if high tension, and also by a smell of over-heated insulation and paint or varnish. When this last indication is noticed, it is advisable to stop the machine at once, otherwise the insulation is liable to be destroyed.

Heating Surface.—That part of a steam boiler exposed to the heat generated by the furnace. Area of heating surface is frequently used to express the horse power. This is figured from the number of square feet of boiler and tube surface, exposed to the action of the fire; the extent of the heating surface of a boiler depends on the length and diameter of the shell and the number and size of the tubes or flues. For the ordinary tubular boiler, fifteen square feet of heating surface has been held to be equal to one horse power; it is

also customary in calculating the heating surface of the shell, to consider that two-thirds of it is exposed to the action of heat. For internal fire-box boilers twelve square feet heating surface is usually allowed per horse power

Heat Insulator.—Any substance which acts as a non-conductor of heat.

Heat Lightning.—Lightning visible in broad flashes near the horizon and unaccompanied by thunder, observed when a storm is at a great distance.

Heat Radiation.—Radiant heat traverses air without heating it.

By means of a simple apparatus it has been ascertained that the proportion of the total heat radiated from different combustibles is as follows:

Heat radiated from	wood,	nearly	1/4
" "	wood charcoal,	"	1/2
" "	oil,	"	1/5

Heat rays proceed in straight lines and the intensity of the rays radiated from any one source, varies inversely as the square of their distance from the source. The rate at which a hotter body radiates heat, and at which a colder body absorbs heat, depends upon the state of the surfaces of the bodies as well as on their temperatures. The rates of radiation and absorption are increased by darkness and roughness of the surfaces of the bodies, and diminished by smoothness and polish. The oiling of smoothly polished castings, as of cylinder heads of steam engines, more than doubles the loss by radiation, while it does not seriously affect rough surfaces.

Heat Unit.—1. Unit quantity of heat; the amount of heat required to raise the temperature of a unit mass of water one degree.

2. The British unit of heat, or British thermal unit (B. T. U.) is that quantity of heat required to raise the temperature of one pound of pure water 1° Fahr., at or near 39.1° F

3. The French heat unit or *calorie* is that quantity of heat required to raise the temperature of one kilogramme of pure water 1° Centigrade, at or about 4° C., which is equivalent to 39.1° F.

One calorie = 3.968 B. T. U.; one B. T. U· = .252 calorie.

Heavy Escape.—In telegraphy, an excesive loss of current due to grounding of the line.

Hecto.—A prefix signifying one hundred times.

Hecto-ampere.—An electric current of 100 amperes.

Hecto-ampere Balance.—A balance ammeter for measuring electric current in terms of hecto-amperes.

Hecto-Watt Hour.—A unit of electrical work equal to 100 watt hours.

Hedgehog Transformer.—A form of transformer devised for reducing the iron loss, having its coils wound upon a core consisting of a bundle of iron wires with their ends spread out like the spines of a hedgehog, so that the lines of force pass partly through the iron and partly through the air.

Heeling Error of Compass Needle.—A further deviation, due to the magnetism of the vessel, to which a ship's compass is liable when the ship is rolling.

Hefner.—The name of the standard light source adopted in the United States and Germany. It is the light given by an amyl-acetate flame adjusted until its tip is 40 mm. above the top of the wick tube. One candle power equals 100/88 hefner.

Hefner-Alteneck Amyl-acetate Lamp.—The lamp of the Hefner standard consists essentially of a cylindrical base for holding the amyl-acetate which is drawn up through a German silver tube by means of a specially prepared wick.

Hefner Standard.—The unit of light adopted as standard in Germany. It is the light given by the Hefner-Alteneck amylacetate lamp.

Helical.—Pertaining to or having the appearance of a *helix* or screw.

Helical Coil.—A coil of wire elongated like the turns of a screw; a helix.

Helical Spring.—A spring whose coils have a gradually decreasing diameter, either lying flat in one plane like a watch spring, or assuming a conical form. The helical spring coiled on a cylinder is generally known as a *spiral spring.*

Heliograph.—An instrument consisting essentially of a movable mirror, employed in signaling, by which beams of sunlight are flashed to a distance in terms of the telegraphic code.

Heliographic Transmission.—A method of signaling by the use of the heliograph.

Heliography.—1. Signaling by the use of the heliograph.

2. The science of describing and mapping the surface of the sun.

Helion Lamp.—A type of incandescent lamp having a filament composed of a core

of carbon which has been treated with a gaseous compound containing silicon. The metal enters the carbon and at the same time forms a surface deposit. The filament is strong, will withstand much higher temperatures than carbon, consumes less watts per candle power, and gives a white light resembling daylight.

Heliostat.—An instrument consisting of a mirror kept in motion by clockwork in such a way as to constantly reflect the rays of the sun in a fixed direction.

Helix.—1. A conducting coil or solenoid.

2. The curve formed by a straight line traced on a plane when the plane is wrapped around a cylinder; as, in a screw thread or the convolutions of a coiled conductor; a screw or spiral.

The length of a helix is found as follows: to the square of the circumference described by the generating point add the square of the distance advanced in one revolution, and take the square root of their sum multiplied by the number of revolutions of the generating point.

Helmholtz, Hermann Ludwig Ferdinand von.—Born 1821, died 1894. A German scientist famous for his researches in physics, and especially for his discoveries in optics. His treatise on *Sensations of Tone* (1863) is considered the most important work on sound of the 19th century. He developed the electromagnetic theory of light, and propounded the generally accepted theory of color. He invented many important methods in practical physics and new physical apparatus.

Helmholtz's Galvanometer.—A tangent galvanometer having two parallel coils symmetrically set on either side of the needle in order to secure uniformity of magnetic field.

Helm Indicator.—An electrical instrument for indicating the position of a ship's rudder.

Helpers.—Unskilled laborers assisting workmen.

Hemispherical Pole Pieces.—Dynamo field magnet pole pieces so shaped as to allow a spherical space between them for the rotation of the armature.

Hemlock.—A variety of spruce or fir, used largely for telegraph poles, found along the northern border of the United States and in Canada. The trees are of medium to large size, giving a light reddish gray timber, free from resin ducts and moderately durable. The wood is rough and splintery. It is used for small scantlings, boarding, and general purposes. A larger sized hemlock, of harder and heavier timber, abounds around Puget Sound, where it is known as *Alaska fir*.

Henley's Quadrant Electroscope.—An electroscope designed by Henley for indicating large charges of electricity; it is a pith ball electroscope approaching an electrometer in its operation.

Henry.—The practical unit of *self-induction*, equal to 10^9 absolute units of induction. It receives its name from J Henry, the American scientist. The self-induction of a circuit is one *henry* when the induced E. M. F. is one volt, while the inducing current varies at the rate of one ampere per second.

The henry is, therefore, the coefficient by which the time rate of change of the current in the circuit must be multiplied, in order to give the E. M. F of self-induction in the circuit. The formula for the henry is as follows:

$$\text{henrys} = \frac{\text{flux}}{\text{amperes}}$$

However, as in the case of the farad, the theoretical unit is too great for practical computations, which involves that the millihenry, or 1-1,000th henry, is the accepted unit. In pole-suspended lines the inductance varies as the metallic resistance, the distance between the wires on the cross arm and the number of cycles per second, as indicated by accepted tables. Thus, for one mile of No 8 B. & S. copper wire, with a resistance of 3.406 ohms, the coefficient of self-induction with 6 inches between centres is .00153, and, with 12 inches, .00175.

Henry, Joseph.—Born 1797, died 1878. An American physicist noted for his researches in electromagnetism. He developed the electromagnet, which had been invented by Sturgeon in England, so that it became an instrument of far greater power than before. In 1831, he employed a mile of fine copper wire with an electromagnet, causing the current to attract the armature and strike a bell, thereby establishing the principle employed in modern telegraph practice. He was made a professor at Princeton in 1832, and during his experimenting then, he devised an arrangement of batteries and electromagnets embodying the principle of the telegraph relay which made possible long distance transmission. He was the first to observe magnetic self-induction, and performed important investigations in oscillating electric discharges (1842), and other electrical phenomena. In 1846 he was chosen secretary of the Smithsonian Institution at Washington, an office which he held until his death. As chairman of the U. S. Lighthouse Board he made important tests in marine signals and lights. In meteorology, terrestrial magnetism, and acoustics he carried on important researches. Henry enjoyed an international reputation, and is acknowledged to be one of America's greatest scientists.

Hercules' Stone.—A name formerly given to the lodestone, or magnetite, the natural magnet.

Hermetical Seal.—The air tight sealing of a glass or other vessel by fusion, as illustrated in the incandescent lamp, so that no air or gas can enter or escape.

Hertz, Heinrich Rudolf.—Born 1857, died 1894. A German physicist noted as the discoverer of electromagnetic waves (1888) which forms the basis of wireless telegraphy. He found that waves produced by the spark of a simple device called the oscillator, could be detected by a loop or square of wire known as the *resonator*, and he was able to show the reflection, refraction, diffraction, and polarisation of the waves. These remarkable discoveries demonstrated the practical possibilities of radio-telegraphy. He also made valuable experiments with electric phenomena in vacuum tubes.

Hertzian Oscillations.—The same as Hertzian waves.

Hertzian Waves.—Electromagnetic waves first observed and studied by Hertz, the German physicist; they originate in a rapidly vibrating or alternating current and are projected far into the surrounding ether. Wireless telegraphy is a practical application of the discovery of the action of ether waves.

Hertz's Axial or Lineal Oscillator.—A variety of Hertz's oscillator having straight conductors instead of metal plates.

Hertz's Oscillator.—An instrument for creating and projecting electromagnetic waves devised by Hertz for his experiments which laid the foundation of wireless telegraphy. It consisted of two metal conductors from each of which extended a rod terminating in a polished knob. By bringing the knobs near together without contact and connecting the conductors to an induction coil a succession of sparks were caused to jump across the gap between the knobs whereby surgings or waves were set up in the ether.

Hertz's Resonator.—A device employed by Hertz in his experiments with electromagnetic waves for the purpose of detecting the waves set up by the oscillator. It consisted of a simple circle or square of wire containing a spark gap capable of adjustment.

Heterochromatic Photometry.—The comparison and measurement of the illuminating intensity of sources of light that differ in color.

Heterogeneous Conductor.—A non-homogeneous or non-isotropic conductor; one that has varying electrical conducting powers in different directions.

Heterogeneous Dielectric.—A non-homogeneous dielectric; one that has varying properties of induction in different directions.

Heteropolar Dynamo.—A bipolar or multipolar dynamo in which the armature conductors, in rotating, pass north and south magnetic poles alternately.

Heterostatic.—A term applied to an electric measuring instrument, such as an electrostatic voltmeter, which employs electrification other than that to be tested, as distinguished from *idiostatic*.

Heterostatic Electrometer.—An electrometer in which there is present electricity independent of that to be measured.

Hewitt, Peter Cooper.—Born 1861. An American electrical engineer and experimenter; inventor of the *mercury vapor electric lamp* (1900), and the *mercury vapor converter*.

Hexad Atom.—In chemistry, an atom having the valency or combining power of six units, i. e., of six atoms of hydrogen.

Hexhead.—A shop term for a hexagon head screw or bolt.

Hexode Working.—In synchronous multiplex telegraphy, the simultaneous transmission of six messages over the same wire.

High Admittance Motor.—An induction motor having a high degree of admittance.

High Commutator Bars.—Commutator segments which, owing to some defect, have surfaces higher than the adjoining ones.

High Duty.—Said of a pumping engine which performs a large amount of work for a given unit of fuel; the number of foot pounds per 100 lbs. of coal was formerly taken as the unit of duty, but in order to eliminate the efficiency of the boiler, and grade of coal, the duty is now usually based on foot pounds of work done per 1000 pounds of dry steam. The term is also applied to those duplex pumps which have vibrating balance cylinders, which permit a high rate of expansion to be used.

High Economy Lamp.—A lamp which has high illuminating power in proportion to the power absorbed by it.

High Frequency.—High periodicity, or exceptionally rapid rate of alternation in an electric current.

High Frequency Currents.—Alternating currents having high periodicity, or rapid rate of alternation.

High Frequency Induction Motor.—An induction motor driven by alternating currents of high frequency.

High Frequency Transformer.—A transformer designed for use with high frequency currents.

High Insulation.—Insulation having a high degree of efficiency.

High Potential Insulator.—An insulator of special size and design usually made of brown glaze porcelain and furnished with a series of deep petticoats, employed on high potential electric circuits; a high tension insulator.

High Potential Push Button.—A push button suitable for use in a high potential circuit.

High Potential Switch.—A switch designed for a high potential circuit.

High Potential System.—An indefinite term applied to a system of electric distribution carrying a pressure exceeding 600 volts. High potentials may reach as high as 88,000 volts or even beyond.

High Potential Testing Transformer.—A transformer designed for the purpose of making high potential tests up to 10,000 volts; it is usually tested up to 35,000 volts, and so constructed as to avoid any danger of breaking down.

High Potential Wires.—Conductors highly insulated so that they may be used in high potential systems.

High Pressure Cylinder.—In a steam engine, the cylinder which first receives steam as it enters an engine from the boiler. The initial cylinder of a compound, triple, quadruple, or other steam engine in which expansion takes place in several successive stages.

High Pressure Engine.—1. A non-condensing engine, so called because the first non-condensing engines carried a high pressure, as compared with contemporary condensing ones as the back pressure due to the atmosphere had to be overcome, while their rivals worked at or near the atmospheric pressure.

2. A simple engine; one not compounded, whether condensing or non-condensing, one which discharges its steam directly into the atmosphere.

High Pressure Incandescent Lamp.—Incandescent lamps for high voltages provided with long filaments, or pairs of shorter filaments joined in series.

High Resistance.—An unusual degree of electrical resistance.

High Resistance Arrester.—A lighting arrester offering a high non-inductive resistance.

High Resistance Magnet.—A magnet wound with long coils of thin wire, offering high resistance.

High Resistance Telephone.—A telephone showing a high degree of resistance.

High Speed.—A shop term, with many significations; as, high speed engines, any engine making over 200 to 300 revolutions per minute. High speed belting applies to belts for fans, centrifugal pumps, etc., in opposition to those for line, counter, and other slowly driving shafts.

High Speed Bearings.—In machinery, bearings whose length is considerably greater than the diameter. Their value consists in the distribution of the excessive friction of rapidly revolving shafts over a large extent of surface, with a consequent diminution of heating.

High Speed Engine.—An indefinite term, originating with the introduction of horizontal or vertical engines which ran much quicker than the older slow moving beam engine; it signifies an engine of small or moderate size, running at a high speed of revolutions rather than a large engine running at a high piston speed. A high speed engine is well adapted to running dynamos either direct coupled or by belt drive, and also any other machine which runs at a high rotative speed.

High Susceptance Motor.—A motor having a light ratio between the magnetic intensity and magnetic force.

High Tension Accumulator.—An accumulator for high voltages.

High Tension Bus.—A bus bar designed for high voltages.

High Tension Cable.—A cable highly insulated so as to be able to convey high electrical pressures.

High Tension Circuit.—An electric circuit adapted to high voltages.

High Tension Fuse.—A fuse for exploding a charge by the use of an electric current of high voltage.

High Tension Insulator.—Insulators of extra size and special design, and possessing great insulating properties, employed in high tension electric circuits. These insulators are usually made of brown glaze porcelain securing a long surface leakage path from wire to pin by a series of deep "petticoats" which increase in diameter towards the top. The topmost shell overhanging the lower ones protects them from rain and the danger of the current "flashing over."

High Tension Switch.—A switch designed for a high pressure circuit.

High Vacuum.—An enclosed space from which the air has been exhausted to such a degree as to create an almost perfect void

High Voltage.—An indefinite term applied to an E. M. F. exceeding 600 volts. Voltages of 6,600, 11,000, 22,000, 33,000, 44,000, 66,000, 88,000, and even higher, are employed on long distance transmission lines.

High Voltage Electromagnetic Generator.—An electromagnetic generator capable of creating a high electric pressure.

High Voltage Incandescent Lamps.—Incandescent lamps designed for high voltages, and provided with specially constructed filaments for the purpose.

Hissing Arc.—An arc lamp which gives off a peculiar hissing sound because the tips of the carbons come too near together; a frying or noisy arc.

"Hitching Up."—An expression used for inserting a "booster" into an electric system.

Hittorf Effect.—The effect produced by Hittorf in his vacuum tube.

Hittorf, Johann Wilhelm.—Born 1824. A German chemist and physicist, distinguished for his investigations relating to the mobility of the ions in electrolysis (1853), the influence of magnetism upon the light in a Geissler tube (1869), and the phenomena of the conduction of electricity through gases.

Hittorf Rays.—The forms of radiation observed in a Hittorf tube.

Hittorf's Solution.—This consists of a solution of iodide in amylic alcohol made with ten per cent. of the salt. It is used as a resistance and is placed in a tube having metallic cadmium electrodes.

Hittorf Tubes.—Vacuum tubes designed by Hittorf for his experiments with electrical discharges through highly rarefied gas.

Hoist, Electric.—A hoist operated by a steam engine with cranks at right angles can only be depended upon for one-half of its rated capacity in starting, as one of the engines may be on a dead center. An electric motor, on the other hand, has no dead centers, and a heavy current in excess of the normal, can be turned into the armature for a few moments without danger.

The power is transmitted to the hoist through an intermediate gear and pinion, which is covered with an iron guard, protecting it from dust, dirt, and liability of accidents. They are particularly convenient where an electric current is easily supplied, and are also useful for contractors and railroad work when it is inconvenient to move boilers about the line The electric wires can easily be run by ordinary workmen, and are always ready to tap at any point.

Holder for Incandescent Lamp.—The socket into which the lamp bulb is fitted.

Holder for Safety Fuse.—A porcelain base for holding a safety fuse.

Holders for Brushes of Dynamo.—Adjustable clutches for holding the commutator brushes of a dynamo. In order to secure sparkless collection of the current, and to prevent undue wear of the commutator, it is needful that the pressure of the brushes upon the latter should be capable of being adjusted to meet requirements; it is also needful that they should be capable of being fed forward as required, and that they be furnished with a movement to permit of the brushes being raised from contact with the commutator when necessary.

Hold Off Spring.—A spring which serves to effect a separation and hold things apart, as distinguished from a spring that preserves a contact.

Hold On Spring.—A spring that serves to keep things in contact, as distinguished from a spring that effects a separation.

Holley, Alexander Lyman.—Born 1832, died 1882. An American engineer and metallurgist. He early became an expert machinist and was employed in a Corliss engine works; later he became editor and part [illegible]) and [illegible] way [illegible] the A[illegible] for m[illegible] steel [illegible] by hi[illegible] parts [illegible] ident [illegible] the n[illegible] Societ[illegible]

Hollow Tile.—Clay moulded into cellular forms and baked. This material is used in fireproof construction for floors, partitions and the casing around pillars and girders. There are two broadly marked classes: (1) porous tiling, in which sawdust and chopped straw are mixed with fine clay, and on burning, the sawdust is consumed leaving the tiling spongy and porous, like pumice stone; (2) hollow pottery, in which the dense clay is moulded into the cellular shapes demanded for constructive work.

Holophane.—A term applied to a type of glass shades and reflectors fitted to electric and other lamps whereby the whole of the light is evenly diffused over a room. The effect is produced by cutting the glass so as to form lenses which refract the light at such angles as to prevent waste.

Holophane Globe.—A glass globe for diffusing light provided with a ribbed surface, the ridges sometimes running vertically on the interior surface, and horizontally on the exterior.

Holtz Influence Machine.—An electrostatic induction machine consisting essentially of two parallel plates of glass, one of which is capable of rapid rotation; it is fitted with suitable inducting and collecting devices.

Holtz, Wilhelm Theodor Bernhard.—Born 1836. A German physicist, distinguished for his contributions to the science of electricity; inventor of the electro-static influence machine (1865) which bears his name.

Home Battery.—In telegraphy, the battery located at the sending or home station.

Home Signal.—A block signal semaphore, placed so as to protect a train standing within the station or section which it covers. Approaching trains are required to stop short of this signal if it stands at danger.

Home Station.—In telegraphy, the *sending station.*

Homogeneous.—Of the same kind or nature; hence homogeneous, as applied to iron, means even-grained.

Homogeneous Conductor.—An isotropic conductor; a conductor that has uniform electrical conducting powers in all directions.

Homogeneous Current Distribution.—A distribution of current throughout a conductor in such a way as to produce uniform electric density through its mass.

Homogeneous Dielectric.—A dielectric having uniform properties of induction in all directions.

Homogeneous Light.—Light having an equal candle power distribution.

Homopolar Dynamo.—A dynamo in which a conductor moves continuously around one pole of a magnet; a unipolar dynamo, of which Faraday's disc is a type.

Hood for Arc Lamp.—A conical tin hood serving the double purpose of sheltering an arc lamp and reflecting its light downward.

Hood Suspension for Arc Lamp.—An arc lamp suspension consisting of a hanger board within a hood.

Hook Switch.—In a telephone set, the yoke support upon which the receiver hangs when not in use; it is provided with a switch lever so adjusted that when the receiver is lifted off the hook, a spring brings it into contact with the terminal of the talking circuit.

Hop System of Space Relations.—A system of space relations assuming that an advance with right to left rotation, in the manner of a growing hop tendril, is *positive.*

Horizontal.—Parallel to the horizon; extending in a flat level surface like that of still water; at right angles to the influence of gravity at any point.

Horizontal Candle Power.—The illuminating power of a source of light in a horizontal direction.

Horizontal Component.—The intensity of a force acting in a horizontal direction.

Horizontal Components of the Earth's Magnetism.—The earth's magnetic force acting upon the compass needle in a horizontal direction.

Horizontal Engine.—One in which the force is exerted in a horizontal direction, or its principal parts lie in a level horizontal plane. A horizontal engine therefore is one whose cylinder lies horizontally, its piston or most important part reciprocating horizontally.

Horizontal Intensity of Earth's Magnetism.—The intensity of the horizontal component at any point on the earth's surface.

Horizontal Intensity of Light.—The illuminating power of a source of light in a horizontal direction or plane.

Horizontal Plane.—A plane parallel to the horizon, without inclination towards it. In perspective, a plane parallel to the horizon, passing through the eye and cutting the perspective plane at right angles.

Horizontal Slit Photometer.—A form of photometer in which the intensity of the light to be measured is passed through a horizontal slit, alternating with the standard light.

Horizontal Tubular Boiler.—In this type, the shell is filled with as many small tubes, varying from two inches to four inches in diameter, as is consistent with the circulation and steam space. In firing, the combustion first takes place under the shell, and the products, such as heat, flame, and gas, pass through the small tubes to the chimney.

Horn Lightning Arrester.—A form of protection against lightning, employed in high tension transmission circuits. A wire bent like a horn is placed at the top of the line pole and connected to ground. It is separated from the line wire by a short distance across which the discharge jumps instead of passing through the highly inductive apparatus in the circuit.

Horns of Pole Pieces.—The projecting terminals of the pole pieces of dynamo field magnets; the polar tips.

Horology, Electric.—The application of electricity to the regulation and control of the movement of clocks.

Horse.—An appliance for supporting a dynamo armature during the process of winding.

Horse Power.—A unit of mechanical power; the power required to raise 550 pounds to the height of one foot in one second, or 33,000 pounds to that height in a minute. Horse power involves three elements: (1) force, (2) distance, (3) time. If we express the force in pounds and the distance passed through in feet, we have a solution of, and the meaning for, the term *foot pounds;* from which it will be seen that a foot pound is a resistance equal to one pound moved one foot.

James Watt was early asked by would-be purchasers as to how many horses his engines would replace. To obtain data as to actual performance in *continuous* work, he experimented with powerful brewery horses, and found that one traveling at 2½ miles per hour, or 220 feet per minute, and harnessed to a rope leading over a pulley and down a vertical shaft, could haul up a weight averaging 100 lbs., equaling 22,000 foot pounds per minute. To give good measure, Watt increased the measurement by 50%, thus getting the familiar unit of 33,000 *minute foot pounds.*

Horse Power, Electric.—A unit of electrical work; being a mechanical horse power expressed in watts. It is equal to 746 watts. To express the rate of doing electrical work in mechanical horse power units, divide the number of watts by 746.

Horse Power Hour.—A unit of work; the amount of work done by one horse power working for one hour; 1,980,000 foot pounds.

Horse Power of Steam Boilers.—The usual value given to the term horse power as applied to boilers, is the evaporation of thirty pounds of water per hour, from feed water of 100° Fahrenheit, into steam at 70 lbs. gauge pressure, which in standard tests is considered to be equal to 34½ pounds of water evaporated from a feed water temperature of 212° F. into steam, at the same temperature. This standard is equal to 33305 B. T. U. per hour. Some engines can develop a horse power on this number of pounds of steam per hour, others, on less, while many require more, hence it is about the present average capacity. Both engineers and steam users have accepted this standard.

Horse Power Transmitted by Leather Belts.—In a single leather belt, not overstrained, a speed of 1000 feet per minute for each inch in width, is estimated to convey one horse power.

There are a number of rules for calculating the horse power of belting; that one to be followed in any particular case is largely a matter of judgment. If the thickness of a belt be increased,

the power transmitted ought to increase in proportion. With large pulleys and moderate velocities this probably holds good, but when a double belt is used on a small pulley, there is not such efficient contact due to the rigidity of the belt, hence, in this case, the power transmitted would not increase in proportion with the thickness. Under these conditions, a double belt of not less than $\frac{7}{10}$ the width of a single belt is assumed to transmit the same power as a single belt.

Horseshoe Electromagnet.—An electromagnet having its core in the shape of a horseshoe, or the letter U.

Horseshoe Magnet.—A magnet bent into the shape of a horseshoe or the letter U, thereby bringing the two poles together so that they act at the same time upon the armature or keeper. A horseshoe magnet is made of hardened steel which retains its magnetism a long time after being magnetised; it will attract and hold pieces of iron and steel. The ends or poles are named north and south. The "armature" or keeper, which is put across the ends, has the peculiar property of keeping the magnetism from becoming weaker.

Hot.—Having the sensation of heat in a high degree, or possessing or communicating sensible heat. In both senses, the term implies a marked degree of heat, the lower degrees being known as *warm*.

Hot Air Engine.—An engine which utilizes the expansive force of heated air. Hot-air engines may be grouped under two heads; those in which the air is heated through a metallic body, and those in which the air is heated in a fire, passing with the products of combustion into a cylinder.

The principle upon which a hot air engine works consists in the alternate heating and cooling of the air employed. The lower part of the vertical cylinder is exposed to the source of heat in such a manner that the internal air becomes rapidly heated and expands, doing work upon a *power piston*. The heated air exhausts through a regenerator or interchanger, where it parts with some of its heat to incoming air and passes into the compression cylinder, where it is rapidly cooled, by means of a water jacket, etc., and is then sent back by another piston through the regenerator to perform the same cycle once more.

Hotel Annunciator.—An annunciator in a hotel office having electric connection with each room.

Hot Gilding.—The electroplating of gold with the aid of heat, a method especially adapted to the gilding of small articles. The use of a hot bath has certain advantages over cold gilding; the deposit is smoother and cleaner and with a deeper color, and generally more durable.

Hot Plating.—Electroplating by the use of a hot bath, as in hot gilding.

Hot Saw.—A circular saw used for cutting iron sections, rails, etc., to the proper length while still heated; any circular saw for cutting hot metals.

Hot Tests.—In metals, the testing of iron and steel bars and plates by bending them *hot* to a certain angle, both with and across the grain.

Hot Tube.—A tube or pipe lined inside with porcelain, to enable it to withstand firing through without excessive oxidization.

Hot Well.—In a condensing engine, a receptacle for the hot water drawn from the condenser by the air pump. Sometimes this water is returned to the boiler, being drawn from the hot well by the feed pump.

Under ordinary conditions, the temperature of the hot well varies from 110° to 120° Fahr.: occasionally as much as 130° degrees is maintained

Hot Wire Ammeter.—An ammeter depending for its action upon the expansion of a wire under the influence of the heat produced in it by the passage of the electric current to be measured.

Hot Wire Instrument.—An electric measuring instrument based on the expansion of a metal by heat. A platinum or platinum silver wire is heated by the passage of a current and thereby caused to lengthen. This elongation is magnified and transmitted to the pointer of the instrument. This form of instrument is applicable equally to direct and alternating currents.

Hot Wire Thermometer.—A thermometer depending for its action upon the unequal expansion of two metals brazed together in the form of a spiral; a bi-metallic thermometer.

Hot Wire Voltmeter.—A voltmeter of the Cardew type at one time generally used for alternating current work. It measures the current by the expansion of a wire when heated by the current passing through it. The slack in the wire caused by the expansion is taken up by a spring, and the motion of the spring is transmitted to the pointer.

House Annunciator.—An annunciator having electrical connection with different parts of a house.

House Mains.—In a system of parallel incandescent lamp distribution for buildings, conductors connecting the auxiliary service conductors with the street mains.

House or Hotel System.—Telephone lines capable of intercommunication, but designed to serve an area usually limited to the premises of a single proprietor. Such a system may have central switchboard in charge of an attendant, or may have a switchboard at every station so that each user may perform his own switching.

House Regulator.—An apparatus for regulating the candle power of the incandescent lamps in a house.

House Service Conductor.—In incandescent light distribution, the service wire running from the street mains to the cut out inside the building.

House Transformer.—A transformer employed to change the character of an electric current to be supplied to a house or other building, usually for the purpose of lighting.

House Wires.—The wires employed in inside wiring.

House Wiring.—In a system of electrical distribution, that portion of the wiring which is within doors.

Howler.—A particularly noisy variety of electric *buzzer*.

H. P.—Abbreviation for horse power, or high pressure.

H-Poles.—A pair of telegraph poles braced together by a cross piece so as to resemble the letter H.

H. R.—Abbreviation for high resistance.

Hub.—The central portion of a wheel from which the spokes radiate, and which is bored for the reception of the axle; the nave of a wheel.

Hughes, David Edward.—Born 1831, died 1900. An English-American electrician and inventor; among his notable inventions are the type printing telegraph (1855), three forms of the microphone (1878), and the *induction balance* (1879).

Hughes' Electromagnet.—A form of electromagnet devised by Hughes for his printing telegraph; it is a permanent horseshoe magnet provided with magnetizing coils upon its pole pieces.

Hughes' Induction Balance.—An apparatus for detecting the presence of a hidden metallic or conducting body by the use of induced electric currents.

Hughes' Microphone.—An early form of the telephone transmitter, consisting of a small pencil of gas carbon loosely held perpendicularly between two carbon blocks fastened to a diaphragm; the *pencil microphone*.

Hughes' Printing Telegraph.—A type printing telegraph devised by Hughes and largely used in Continental Europe.

Hughes' Theory of Magnetism.—A theory proposed by Hughes that magnetism is an original property of matter, every molecule of matter being assumed to exist as a natural magnet. In a magnetized substance the poles of these molecular magnets are supposed to be arranged in the same direction, and in an unmagnetized body in opposite directions thus neutralizing each other.

Humidity.—The watery vapor always present in the atmosphere; it varies with the temperature, being greater during warm weather. The degree of saturation, or relative humidity of the air, is determined by the use of the wet and dry bulb thermometers.

The feeling of wetness or dampness in the air does not depend mainly on the absolute amount of vapor present, but chiefly on the nearness of that vapor to its *saturation point* Thus, on a warm day in summer, there is probably much more vapor present than on a damp winter day. In the latter case, the temperature of the air is very little above the dew point; that is, the air is nearly saturated and a very small fall of temperature will cause the vapor to be deposited as moisture. On the summer day, a greater fall is needed before the dew point is reached and the air begins to feel damp.

Hummer, Electric.—An electric *buzzer*.

Humming.—A sound sometimes made by a dynamo or motor because of vibrations of the laminations of the pole pieces or armature core.

Hunning's Transmitter.—The earliest form of carbon dust transmitter. It was devised by Henry Hunnings in 1881, and in one form or another has displaced all types previously invented. In this transmitter the variable resistance medium consisted of a mass of finely divided carbon granules held between two conducting plates

Hunting.—1. A term applied to the state of two parallel connected alternators running out of step, or not synchronously; see-sawing.

2. A condition which sometimes arises in rotary converters. It is due to the development of a periodic vibration in speed that causes fluctuations in the direct current voltage, often giving rise to excessive sparking. Hunting may be remedied by putting heavy copper bridges between the pole tips and by placing a heavy copper ring around the pole force.

Hydraulic Crane.—A crane driven by a hydraulic ram or piston; the stroke of the ram being multiplied several times by means of a pulley system, thus giving a long rapid lift.

Hydraulic Driving.—The driving of electric machines by power derived from falling water, as in a hydro-electric plant.

Hydraulic Jack.—A jack used for lifting heavy weights, the load on which is moved by a hydraulic plunger instead of a screw. The plunger is actuated by a small pump, whose water supply is contained in the head of the jack. This has been called the seventh mechanical power.

Hydraulic Lime.—One possessing the property of hardening under water. Limes containing 8 to 12 per cent. of silica, alumina, etc., set slowly in water, those containing 12 to 20 per cent. of the same ingredients set in six or eight days, those termed eminently hydraulic, and possessing 30 to 50 per cent. of foreign matter harden in 2 to 4 days.

Hydraulic Pivot.—A film of oil or water forced under the end of an upright shaft to absorb friction and sustain the weight.

Hydraulic Ram.—A device whereby the energy of a fall of water is made to force a portion of the water to a great height. The water working the ram is supplied through a sloping pipe, and escapes through an opening; when its velocity exceeds a certain rate, it closes this opening by means of a balanced valve, which is made as light as consistent with strength; the sudden stoppage creates intense pressure in the ram and opens a delivery valve into an air vessel, and thence drives the water through the delivery pipe to its destination. As soon as equilibrium is restored, the delivery valve closes, the waste opens and the cycle recommences.

Hydraulics.—That branch of the science of engineering which treats of water in motion, and the application of its laws to the industries; as to hydro-electric generation.

Hydraulic Storage.—A storing of mechanical energy by accumulating water in elevated reservoirs.

Hydraulic Transmission.—Transmission of mechanical power by means of pipes conveying a pressure of water.

Hydraulic Turbine.—One driven by water pressure or impulse, as distinguished from one actuated by steam or other fluid.

Hydrocarbon.—A compound of hydrogen and carbon; the possible number of these compounds is infinite, and the known number very large. The most important are: (1) paraffins, (2) olefines, (3) acetylenes, (4) benzines or aromatic series. To the first belong gases, liquids and solids, like marsh gas, petroleum, ozokerite and jet. Illuminating gas, generally consists of hydrogen combined with olefines and acetylenes. The benzines in one form or another cover an immense range, carbolic acid, essential oils, tannic acid, all being formed therefrom.

Hydrocarbon Treatment of Filaments.—Applying the *flashing* process to incandescent lamp filaments.

Hydrochloric Acid.—A colorless gas with keen acid smell. It liquefies under a pressure of 40 atmospheres at 10° and solidifies at 115° The gas is very soluble in water and its solution behaves as a strong acid It is obtained on a large scale by heating common salt with sulphuric acid. Hydrochloric acid is used for producing chlorine; in preparing the chlorides of various metals; in dyeing and tissue printing; in the manufacture of coal tar colors; in electroplating, a dilution is used for pickling iron and zinc; and for many other purposes. Also known as *muriatic acid* and *spirits of salt.*

Hydrocyanic Acid.—Prussic acid, one of the most poisonous substances known. Its salts are called cyanides such as potassium cyanide and mercurous cyanide. Potassium cyanide is largely used in extracting gold and in electroplating.

Hydrodynamics.—That branch of mechanics which treats of the laws of motion and action of water and other liquids.

Hydro-electric Bath.—In electro-therapeutics, a bath having one electrode connected with the metal of the tub and another for application to the patient's body.

Hydro-electric Generator.—A term for a generating set or unit in which a dynamo is coupled directly to a turbine or other water wheel.

Hydro-electric Machine.—An experimental machine for generating electricity by the friction of jets of steam issuing from an insulated boiler through wooden nozzles against a metal comb.

Hydro-electric Plant.—A power station driven by water for the generation of electricity. The impulse wheel is used for high heads, the turbine for low heads, and either one for moderate heads. At Niagara Falls are five important examples of turbine wheel development, each plant having an ultimate output of over 100,000 horse power, and distributing electricity for power and lighting purposes over a wide area.

Hydro-electro-therapeutics.—The application of electricity and water for curative purposes; usually applied in the form of a bath furnished with suitable electrodes, one applied to the tub and the other to the body of the bather.

Hydrogen.—A colorless, odorless, tasteless gas, the lightest body known. Its specific gravity is taken as 1, air being 14.4. It is combustible, burning with an almost invisible flame, if pure, and forming water by union with the oxygen of the air; it is a non-supporter of combustion. Hydrogen liquefies under great pressure and low temperature, solidifying at —431° Fahr.

Hydrogen Flame.—The flame of burning hydrogen supplied with oxygen, producing an extreme heat sufficient to melt many refractory substances. It is usually known as *oxyhydrogen* flame.

Hydrogen Voltmeter.—A voltmeter depending for its action upon the amount of hydrogen liberated under certain conditions.

Hydrometer.—An instrument for measuring the specific gravity of liquids. It is usually constructed of glass and consists of: 1, a graduated stem, a fine tube of uniform diameter; 2, a bulb or enlargement of the tube containing air; 3, a small bulb at the bottom, containing shot or mercury which causes the instrument to float in a vertical position. The graduations represent either specific gravities, or the numbers of an arbitrary scale, as in Baumé's, Beck's, Twaddel's, etc.

Hydrometric Telegraph.—An apparatus for signaling by the use of water pressure.

Hydro-platinum Rheostat.—A rheostat offering water resistance provided with electrodes of platinum.

Hydrostatic Balance.—A balance for weighing substances in water, for the purpose of ascertaining their specific gravities.

Hydrostatic Bed.—In hydraulics, a *water* bed; as, that of a pond.

Hydrostatic Level.—An ingenious method of ascertaining whether walls, etc., are level with each other, although wide spaces intervene. Two large graduated vessels, resembling beakers, are connected near their bases by flexible rubber tubes. On filling them with water and placing a beaker on either wall to be compared, the height in each graduated vessel will at once proclaim the relative level of each surface.

Hydrostatic Paradox.—The principle that any quantity of fluid however small may balance any weight however great.

Hydrostatics.—That branch of physics which treats of the laws governing fluids at rest, as distinguished from hydraulics, which refers to them in motion.

Hydrostatic Wire Testing Machine.—A machine for testing the strength of wires by hydraulic pressure.

Hydrotasimeter, Electric.—An electrical instrument for indicating at a distance the height of a water level.

Usually a float is placed in the water and connected with an electric circuit. The action of the float sends positive impulses when rising, and negative impulses when falling; an index registers these. Positive currents produce a motion in one direction and negative currents a motion in the opposite direction.

Hygrometer.—An instrument for measuring the proportion of aqueous vapor in the atmosphere; a usual form is that known as the wet and dry bulb thermometer. This consists of two equal thermometers mounted side by side, the bulb of one being kept moist by means of a wick tied around it, which dips into a vessel of water. Owing to the evaporation from this bulb, its temperature is lower than that of the other, the difference depending upon the amount of moisture in the air. There is no real relation between the hygrometric readings and the actual state of the atmosphere, but the hygrometric state is deduced from reference to tables compiled from accurate observations with most elaborate instruments.

Hypothesis.—A tentative theory or assumption adopted for the explanation of certain facts, and serving as the basis of further investigation.

Hypsometer.—An instrument for measuring the height of mountains, consisting

essentially of a sensitive thermometer by which the temperature of the boiling point of water at a given elevation is determined; a *thermo-barometer.*

Hysteresial Dissipation of Energy.—The loss of energy due to hysteresis in a magnetic substance.

Hysteresimeter.—A device for measuring hysteresis loss by mechanical torque. It consists of a U shaped magnet which can be rotated around a vertical axis. The sample sheets of iron or steel to be tested are mounted in the form of a ring between the poles of the magnet upon a support which tends to revolve, but is held by a spring. When the magnet rotates the sample under test turns by an angle at which the hysteresis torque balances the pull of the spring. Other forms of testing apparatus employ the same principle.

Hysteresis.—A peculiar quality of an iron core, such as an armature core undergoing rapid reversals of magnetism, by which there occurs an expenditure of energy which is converted into heat. This loss of energy is due to the work required to change the position of the molecules of the iron, and takes place both in the process of magnetizing and demagnetizing; the magnetism in each case lagging behind the force; *static* hysteresis as distinguished from *viscous* hysteresis.

Ewing gives the value in ergs for the energy dissipated per cubic centimeter, for a complete cycle of doubly reversed, strong magnetization, viz.:

Very soft annealed iron	9,300	ergs
Less " " "	16,300	"
Hard drawn steel wire	60,000	"
Annealed steel wire	70,500	ergs
Same steel, glass hard	76,000	"
Piano steel wire, normal temper	116,000	"
Same, annealed	94,000	"
Same, glass hard	117,000	"

Hysteresis Coefficient or Constant.—The amount of energy lost in magnetizing and demagnetizing a unit volume of material is the hysteresis coefficient of the material.

Hysteresis Loop.—Loops plotted in graphic curves of cycles of magnetization to illustrate the waste of energy due to hysteresis.

Hysteresis Losses.—Waste of energy due to hysteresis in a magnetic substance.

Hysteresis Measurer.—An instrument for estimating the coefficient of hysteresis of a magnetic substance.

Hysteresis Meter.—The same as *hysteresimeter.* An instrument for measuring hysteresis loss by mechanical torque.

Hysteretic Activity.—Activity engaged in causing hysteresis.

Hysteretic Cycle.—A cycle of magnetization and its reversal, involving hysteresis.

Hysteretic Lag.—Lagging of magnetization caused by hysteresis.

I.—1. Abbreviation for intensity of magnetization.

2. A symbol for the strength of electric current.

Ia, Ia Metal.—A nickel copper alloy employed in the construction of electrical instruments, resistances, etc. It is not affected by moisture; is permanent and has a very low temperature coefficient of resistance.

I-Armature.—An armature having a core resembling the letter I; *a girder or* H *armature.*

I-Beam.—A rolled joist or beam resembling the capital letter I in cross section. Such beams are economical of material through elimination of redundant material near the neutral axis.

Ice Clearer.—A trolley wheel specially constructed for removing ice from the trolley wire.

Ideal Solenoid.—A solenoid conceived to be built up of a system of independent circular currents, equal, parallel, and uniform in direction.

Identical Electrode Cell.—A variety of double fluid voltaic cell, having both electrodes of the same metal; a one-metal cell.

Idle Electrics.—A name formerly given to substances, such as, glass, amber and resin, which become electrified by friction.

Idiostatic.—A term applied to an electric measuring instrument, such as an electrostatic voltmeter, in which the only electrification present is that which is to be tested, as distinguished from *hetrostatic.*

Idiostatic Voltmeter.—A voltmeter in which there is present only the electricity to be measured, as distinguished from a heterostatic electrometer.

Idle Coil.—In armature winding, when the number of slots does not satisfy the winding formula, an extra coil is inserted which serves to give the armature symmetry and adds to its strength, but which carries no current. The idle coil may be connected to an extra commutator bar on one side, or it may be insulated on both ends.

Idle Current.—A name sometimes given to that component of an alternating current at right angles to the E. M. F. and contributing nothing to the power.

If the angle of lag be cos ϕ, then the power in watts is E C cos ϕ. The product C cos ϕ may be regarded as the resolved part of the current, which is in the same phase as the electromotive force E, while the remaining component of the current C sine ϕ differs in phase from the electromotive force by 90°. The product E C sine ϕ = O, and C sine ϕ *is the idle current;* also called the *wattless* current.

Idle Plug.—A telephone switchboard plug not in use.

Idle Poles.—Poles in a Crookes' vacuum tube, which are not intended to produce an electric discharge, but are introduced for other experimental purposes.

Idler.—1. In gearing, a tooth wheel occupying an intermediate position in a train, which communicates motion from the driver to the follower.

2. A pulley or drum which supports a belt or prevents it from coming into contact with a stationary part.

3. An adjustable pulley which bears against a belt for the purpose of preserving proper tension.

Idler Wheel.—A wheel introduced into a train of gearing for the purpose of filling up a gap, or of changing the direction of motion without influencing the velocity ratio; called also *cock wheel.*

Idle Wire.—1. A wire which does not convey a useful electric current.

2. An armature coil which does not generate electromotive force; *an idle coil.*

Igneous.—Caused by fire; a term applied to such rocks as lava, granite, quartz, etc., which were formed under the action of heat.

Igniter.—1. A device, either portable or attached to a lamp or fire to light it; an electrical or other attachment to internal combustion engines for ignition of the charge.

2. A strip of carbon connecting the ends of the parallel carbons of an arc lamp of the Jablochkoff type, whereby, upon the passage of the current, an arc is formed.

Ignition.—1. The act of igniting, kindling, or setting on fire.
2. The state of being ignited or kindled.

Ignition, Electric.—A method of firing the "mixture" in an internal combustion engine by the aid of an electric spark. It is largely used in automobile work in which two systems are recognized, viz.: the *primary*, or "make and break" spark, also called "touch-spark", etc., and the secondary or "jump-spark." These systems require an electric source such as a battery or magneto.

Ignition Plug.—A screwed plug inserted into the cylinder wall or head of an explosive engine; it has two electrodes or *spark points*, one of which is grounded to the cylinder and the other insulated.

I. H. P.—Abbreviation for indicated horse power.

i. i.—A signal in telegraphy for indicating the separation of the words of a message from the signature of the sender.

Illuminant.—That which illuminates or produces light.

Illuminated Dial Instrument.—An instrument having a translucent dial, which, when lighted up from within, renders the pointer and scale visible in the darkness.

Illuminating Engineering.—The practice of producing and distributing artificial light consistently with high scientific standards.

Illuminating Gas. — Hydrocarbon gas supplied through piping from a central source or place of manufacture, and whose flame is used for lighting purposes. It is generally obtained by means of the destructive distillation of bituminous coal in closed retorts, yielding a number of very complex hydrocarbons. Water gas is made by the decomposition of steam blown through red hot fuel, yielding hydrogen and carbon monoxide. The two processes are frequently used in conjunction, the coke or residue from coal gas manufacture furnishing the fuel for the water gas. Oil gas is made by spraying petroleum in heated retorts, converting the liquid into a fixed gas, burnt either by itself, or used to enrich coal or water gas. In certain places natural gas, principally methane, issues from the earth and is used as an illuminant.

Illuminating Power.—The amount of illumination which a source of light is capable of producing stated in terms of a unit of illumination.

Illumination.—The state of being lighted up, or illuminated.

Illumined Dial Measuring Instrument.—An instrument for electrical measurement having a translucent dial which may be so illuminated as to render the index and scale visible in the darkness.

Illumined Electrode.—In a selenium cell, the electrode which responds to the action of light.

Illuminometer.—A simple form of photometer for comparing illuminations with approximate accuracy. It works on the principle of an extinction photometer, the light being varied until certain test characters become invisible.

Image, Electric.—As defined by Maxwell: "An electrified point or system of points on one side of a surface, which would produce on the other side of that surface the same electrical action which the actual electrification of that surface really does produce."

Imbibition Currents.—Currents in tissues due to the absorption of fluids.

Immersion Gilding.—A method of gilding an object by simply immersing it in a proper *solution of gold*.

Immersion Objective.—The objective of a microscope from which the object to be examined can be suspended by a drop of clear liquid.

Impact.—The force of the collision of one body against another. Impact is *direct* and *oblique*. When a body hits a plane surface, it rebounds at an angle equal to that at which it approached the plane. If two perfectly elastic bodies impinge on each other, their relative velocities will be the same after impact as before; that is, they will recede from each other with the same velocity with which they approached.

Impedance.—The total opposition in an electric circuit to the flow of an alternating current; being made up of the actual or ohmic resistance and the apparent resistance due to self-induction.

The self-induction part of the impedance offered by a coil varies with the rate at which lines of force cut the convolutions; that is to say, it varies with the rate of alternation, and also with the amplitude and shape of the current wave. If

an alternating current be applied to a coil having a resistance of R ohms and a coefficient of self-induction of L henries, when the current curve follows the sine law, the

$$\text{Impedance} = \sqrt{R^2 + p^2 L^2}$$

in which, $p = 2\pi n$, where n represents the number of complete alternations per second.

Impedance Circuit.—An electric circuit in which impedance exists.

Impedance Coil.—A name given to a *reactance* or *choke* coil which is sometimes introduced into a circuit, as with alternating current electric lamps, in place of a resistance. It consists of a coil of wire wound upon an iron core.

Impedance Factor.—The ratio of the impedance to the ohmic resistance in an electric circuit.

Impedance Rush.—The sudden burst of current which enters an inductive circuit at the moment it is closed.

Impediment.—The combined resistance in a circuit including ohmic resistance, self-induction, and capacity.

Impenetrability.—That property of matter which renders it impossible for two bodies to occupy the same space at the same time.

Imperfect Earth.—A fault in an electric circuit due to an imperfect grounding or connection with earth through a defect in the insulation; a partial earth.

Impinge.—To fall or dash against; to clash with.

Implement.—Whatever may supply a want; especially an instrument or utensil, as supplying a thing requisite to an end; as, an implement of industry.

Imponderable.—Without weight; a term little used in modern science, but formerly applied in general to heat, light, electricity and magnetism, which were regarded as material substances having no weight.

Impounding Reservoir.—In hydraulics, a large reservoir where water supply from rivers may be received preparatory to filtering; the impounding reservoir is large enough to permit some preparatory settling.

Impregnated Carbon.—Carbon prepared for use as an electrode in the flaming arc lamp. In order that the carbon shall give off at the temperature of the arc a strongly luminous vapor, it is sometimes impregnated with common salt which causes it to give, in the arc, a brilliant yellow flame. Other materials are also used for impregnating the carbon, especially calcium fluoride which produces a golden light of great intensity.

Impregnated Pole.—A wooden pole for carrying line wires, which has been protected against decay by having creosote or other preservative forced into the fiber of the wood. The life of the pole may in this way be increased from three to tenfold.

Impressed.—Brought to bear upon; pressure exerted upon.

Impressed Electromotive Force.—The E. M. F. put upon a circuit to create a current, as distinguished from any counter electromotive forces in the circuit due to self-induction, etc.

Impressed Field.—An electric or magnetic field applied to a body or area in order to produce other fields of force.

Impulse.—An electromotive force which produces an impulsive rush of electricity or impulsive discharge, as distinguished from an ordinary E. M. F. which produces a steady current.

Impulse Turbine.—In hydraulics, a motor in which the fluid is directed by means of a series of nozzles, the vanes of which it drives.

Impulsion Effect.—The effect upon a photo-electric cell produced by mechanical or electromagnetic impulses.

Impulsive Current Rush in Inductive Circuit.—A rush of electric current which is liable to take place when a transformer is switched into an active conductor.

Impulsive Discharge.—A disruptive discharge which occurs when a difference of potential is suddenly produced in a conductor.

Impulsive Impedance.—The impedance or opposition offered to an oscillating discharge, as of a Leyden jar.

Impulsive Inductance.—The inductance of a circuit in which an impulsive discharge takes place.

Impulsive Load.—A load suddenly applied to a structure, subjecting it not only to the actual dead weight, but also to the accumulation of energy gathered in its motion. Also called *live load.*

Impulsive Permittance.—The permittance of a circuit upon the passing of an impulsive discharge.

Inactive Molecules.—Those molecules of an electrolyte which are not decomposed by the action of the electric current, and hence do not produce ions at the electrodes.

In Bridge.—A parallel or multiple connection in a circuit, as distinguished from a series connection.

Incandesce.—To give light, or glow, at a white heat.

Incandescence.—The glowing of a substance when heated white hot.

Incandescence, Electric.—The glowing of a substance when heated white hot by an electric current. Incandescence is produced by the passage of a current of high intensity through a conductor of high resistance; the temperature in a non-homogeneous conductor is highest in those portions where the resistance is highest and the radiation smallest.

Incandescent.—That which gives light or glows at a white heat.

Incandescent Ball Electric Lamp.—An incandescent lamp having a carbon ball within an exhausted glass bulb; the carbon becoming luminous by the influence of high frequency electrostatic waves.

Incandescent Bombardment Lamp.—An electric lamp in which the incandescence is produced by the molecular bombardment of an electric discharge in a vacuum.

Incandescent Circuit.—The electric circuit which operates incandescent lamps.

Incandescent Cut Out.—A cut out or safety fuse employed within a circuit for incandescent lamps.

Incandescent Electric Lighting.—Lighting by the use of incandescent lamps.

Incandescent Filament.—A thin wire or filament of infusible conducting material which is caused to incandesce within the bulb of an electric lamp.

Incandescent Generator.—A dynamo employed to operate an incandescent lamp system.

Incandescent Lamp.—An electric lamp giving light from the incandescence of a slender filament consisting of some conducting refractory material enclosed within an exhausted glass chamber. Carbonized paper or bamboo fiber was at first used for the filament, but this was superseded by carbonized cellulose which held the field for many years. Efforts to secure a filament of greater efficiency have resulted in important developments, among which may be mentioned the *metallized* filament in which the carbon is converted to graphite, and various filaments composed of rare metals as used in the osmium, tantalum, tungsten and other new lamps.

Incandescent Lamp Base.—The brass base which is attached to the lamp bulb by plaster, and which contains the contact for bringing the filament into connection with the electric circuit.

Incandescent Lamp Cord.—The flexible cord composed of two insulated conductors, employed in connection with pendant incandescent lamps.

Incandescent Lamp Socket.—The socket provided with contacts, into which the base of an incandescent lamp is designed to fit.

Incandescent Mantle Burner.—A lamp provided with a mantle of inflexible gauze which becomes incandescent in a Bunsen flame.

Inch.—A measure of length, the twelfth part of a foot, commonly subdivided either decimally, as for scientific purposes, or into eighths, sixteenths, etc. It was also formerly divided into twelve parts, called *lines*, and originally into three parts, called *barleycorns*, its length being supposed to have been determined from three grains of barley placed end to end lengthwise.

Inch Pound.—In mechanics, a unit of calculation signifying one pound lifted one inch.

Inch Ton.—In mechanics, a unit of calculation denoting one ton lifted one inch.

Inclination Compass.—An inclinometer, or instrument, having a magnetic needle

moving only in a vertical plane, designed to indicate the magnetic inclination or dip at any point on the earth's surface; also called *inclination magnetometer*.

Inclination Map.—An isoclinic chart upon which is drawn a system of lines passing through all the points on the earth's surface which have the same magnetic inclination or dip.

Inclination of Magnetic Needle.—The dip of a magnetic needle; the angle which a magnetic needle, turning upon a horizontal axis, makes with the horizontal plane, due to the fact that in most places the lines of force are not horizontal. In the northern hemisphere it is the N pole of the needle which is depressed; in the southern hemisphere it is the S pole.

Inclined Plane.—A slope or flat surface inclined to the horizon, on which weights may be raised. By such substitution of a sloping path for a direct upward line of ascent, a given weight can be raised by a power less than itself. The simplest example we have of the application of the inclined plane is that of a plank being raised at the rear end of a cart for the purpose of rolling in heavy articles, as barrels or hogsheads.

Inclinometer.—1. An inclination compass.

2. An instrument for measuring the rates of slopes or inclinations, by means of a spirit level and a graduated arc. A *clinometer* or *batter measure*.

Incombustible.—Not capable of being burned, or consumed; as, asbestos is an incombustible substance.

Incoming Call.—A telephone call received at a station from without, as distinguished from an outgoing call, or one issuing from the station.

Incoming Call Trunk Line.—A telephone line employed at a central station for receiving incoming calls.

Incoming End.—The end of a telephone line at which incoming calls are received by an exchange.

Incoming Junction Board.—In a central telephone station, a switchboard for the reception and distribution of incoming junction wires.

Incoming Lines.—Telephone lines by which calls are received at an exchange.

Incoming Signals.—Telegraphic messages which arrive at the home station.

Incoming Wires.—Any wires leading into a place or apparatus.

Incomplete Circuit.—An open circuit, as distinguished from a complete or closed circuit.

Incompressibility.—In hydraulics, a property of liquids which is utilized for the transmission of power in hydraulic cranes, lifts, pistons, etc. The compressibility of water under the pressure of one atmosphere is from .00004 to .00005, decreasing with increase of temperature, an amount altogether inappreciable in practice.

For each foot of pressure pure water will be diminished in volume .0000015 to .0000013. The compressibility of water is so small that even at a depth of a mile, a cubic foot of water will weigh only about half a pound more than at the surface.

Inconductivity.—The quality of being non-conducting.

Increased Electric Irritability.—An abnormal sensitiveness on the part of the tissues of the human body to electric irritation.

Increment.—The act or process of increasing; growth in bulk, quantity, number, value or amount.

Increment Key.—A telegraph key which not merely closes a circuit when contact is made, but produces an increment or increase in the line current.

Increment Key for Quadruplex Telegraphy.—A telegraph key which increases the strength of the line current for the operation of distant instruments in a quadruplex system.

In Current of Telephone Relay.—The current which a telephone relay gets for further transmission.

Independent Circuits.—Electrical circuits independent of other circuits.

Independent Two Phase System.—A polyphase alternating current transmission system consisting of two separate circuits derived from two armature windings in quadrature with each other, or from a continuous armature winding tapped at four equidistant points; the two phase four wire system.

Index of Refraction.—In the passing of light from one medium into another, the ratio between the sines of the incident and refracted angles; the refractive index.

India Rubber.—An elastic gummy substance derived from the milky juice of a variety of tropical trees and plants. The juice resembles cream as it issues from incisions made in the bark. The best rubber, known as *Para*, comes from Brazil, Bolivia and Peru. Many other grades are obtained from South America and Africa, while successful attempts at cultivation have taken place in Ceylon, and the Straits Settlements. India rubber has valuable insulating properties, and is largely used in covering electric cables, etc.

As good india rubber is expensive, a large number of substitutes have been tried for insulating purposes. Some of them are fibrous in construction, and are impregnated with an insulating oil. Their specific resistances are lower than those of rubber, but this is not a serious drawback providing the coating be sufficiently thick. These substitutes are not impervious to moisture and require a waterproof covering, which usually consists of a lead sheathing.

Indicated Horse Power.—The measure of the work done within the cylinder of an engine. The indicated horse power is calculated from indicator cards which show the variations of steam pressure within the cylinder. The formula for indicated horse power is:

$$\text{I. H. P.} = \frac{plan}{33000}$$

in which, p = mean effective pressure on the piston in lbs. per sq. in.; l = length of stroke in feet; a = area of piston in sq. ins.; n = number of revolutions per minute for a single acting engine, and number of strokes per minute for a double acting engine. For accuracy, subtract one-half of the piston rod area from the piston area. The formula is easily remembered since the letters spell the word "plan."

Indicating Bell.—An electric bell which releases an annunciator drop when it rings, so that it may be identified among other bells.

Indicating Bell Annunciator.—An annunciator drop which acts in connection with an indicating bell.

Indicating Lamp.—A lamp in an electric circuit which is designed to indicate varying conditions of the circuit by the quality of its own light.

Indicating Push Button.—A push button provided with an electromagnetic vibrator which makes a noise when the button is pressed to show that the current operates, and the distant bells ring properly; a sounder push.

Indicating Switch.—A switch which indicates whether its circuit is open or closed.

Indicating Wattmeter.—An electrical instrument for measuring power developed in a circuit, and designed to show instantaneous values of power, or the rate at which energy is consumed in a circuit.

Indicator.—1. Any form of annunciator.

2. An instrument by which the working steam records its working pressure, from which the power of the engine may be calculated. It consists of a small cylinder communicating by a cock with the cylinder of the engine, and fitted with a piston, to which a pencil is attached. The roller upon which a card is fastened, is oscillated forward and backward by a cord attached to the piston rod of the engine. As the pencil rises by the steam pressure, and is brought back by a graduated spring when that pressure is reduced by expansion and condensation, a figure representing the pressure at each point in the stroke of the engine, is traced upon the card.

Indicator Card.—The card of a steam engine indicator which shows the pressure curves automatically traced, whereby the indicated horse power of the engine may be determined. The diagram is shaped like a foot; its length represents the stroke, and its height the steam pressure in pounds. The average pressure, cylinder area, and piston speed are the elements for calculating the horse power.

Indicator Diagram.—In steam engineering, a diagram of work traced by the pencil of the indicator upon an indicator card. From it are deduced both the behavior and the mean effective pressure of the steam in the cylinder and thence the indicated horse power. To obtain the mean effective pressure, the area of the card is divided transversely by equidistant ordinates, ten or more as most convenient, perpendicular to the atmospheric line. Now, with a scale corresponding to the spring with which the diagram was taken, measure the pressure in the center of each of these divisions The measurement being taken between the steam expansion and exhaust lines The average of all the measurements will give the *mean effective pressure*.

Indicator Dial, Electric.—An electromagnetic indicator which shows upon its dial the state of a section of railroad which forms a part of an electric block signaling system.

Indicator, Electric.—1. An instrument, often consisting of a dial over which a magnetic needle swings, designed to indicate to operators or attendants, the condition of

a system, machine, or any detail in mechanical or electrical engineering.

2. An annunciator.

Indicator Flap.—A disc of light metal which swings over the self-restoring indicator of a multiple telephone switchboard.

Indicator Spring.—A device used in operating a steam engine indicator; it is the most vital part of the instrument, being used to show the varying pressure of the steam in the engine cylinder.

Indifferent Electrode.—An electrode employed in electro-therapeutics merely for the purpose of closing the circuit through the part of the body to be treated, as distinguished from the electrode which actually applies the treatment.

Indirect Distribution.—Electric distribution which involves the introduction of various intermediary devices between the dynamo and the receptive devices.

Indirect Electrolysis.—Chemical decomposition occurring after the action of electrolysis, as distinguished from the electrolysis itself.

Indirect Excitation.—A method of applying electric excitation to a muscle by placing the electrode upon the nerve leading to that muscle.

Indirect Welder.—An electric welder which has an apparatus for heating, consisting of a step-down transformer which lowers the pressure while increasing the volume of the current.

Individual Signal.—A selective signal; a signal designed for calling any one of the stations connected on one circuit, so that only the station for which the call is intended shall hear it.

Individual Telephone Switchboard.—One of the separate sets of connections of a multiple switchboard.

Individual Transformer.—A transformer serving for a single electro-receptive device or circuit.

Indoor Transformer.—A transformer set up within a building.

Induced.—Brought about by *induction*, as when a body receives an electric charge by the influence upon it of a neighboring charged body.

Induced Atomic or Molecular Currents.—Currents conceived to be produced in the particles of a magnetic substance when influenced by the presence of lines of magnetic force.

Induced Coil.—The secondary coil of a transformer.

Induced Current.—An electric current set up in a circuit by cutting lines of force; a current caused by electromagnetic induction; as, in an induction coil when the strength of a current flowing through the primary winding varies, magnetic changes take place in the core and surrounding field which induce currents in the other or secondary windings.

Induced Current of Transformer.—The electric current produced in the induction coil of a transformer.

Induced Direct Current.—A break induced or direct induced current; an extra current in the same direction as the original, induced in a circuit when it is broken.

Induced Electric Surgings.—Electric oscillations set up in a conductor because of similar vibrations taking place in a neighboring conductor.

Induced Electromotive Forces.—Electromotive forces due to electromagnetic induction.

Induced Electrostatic Charge.—An electric charge received by a body brought within the influence of an electrostatic field.

Induced Lightning Discharge.—The back or return stroke of lightning; a discharge which occurs after the main discharge as the result of induction produced in the neighborhood of the original stroke.

Induced Magnetic Flux.—Magnetic flux or the number of lines of force caused by induction.

Induced Magneto-motive Force.—Magnetic pressure caused by induction.

Inducing.—Bringing to bear the electrical, or magnetic influence of induction.

Inducing Circuit.—An electric circuit which produces induction in another circuit.

Inducing Coil.—The primary winding of a transformer.

Inducing Current of Transformer.—The current in the primary winding of a transformer.

Inducing Magnet.—The permanently magnetized armature of a polarized relay.

Inductance.—The coefficient of self-induction, the capacity which an electric circuit has of producing induction within itself. Inductance is considered as the ratio between the total induction through a circuit to the current producing it, and may be measured in terms of a unit called the *henry*. When the henry is too large for convenience, the *milli*-henry, or one-thousandth part of a henry is used. The effect of inductance is to cause the current to lag behind the electromotive force.

Inductance Box.—A box provided with graded inductances for measuring inductance in an electric circuit.

Inductance Coil.—A choking coil; a coil of wire with an iron core used in an alternating current circuit to impede the current.

Inductance Reactance.-Reactance present in a self-induction coil.

Inducteous Body.—A term suggested by Faraday to describe a body which receives an electric charge upon coming into the sphere of influence of another electrified body.

Induction.—The influence exerted by the interference of fields upon fields or fields upon conductors, such that an electric or magnetic state may be induced in a body by the proximity, without contact, of an electrified or magnetized body.

Inductional Igniting Device.—A device for producing a spark by electric induction.

Induction Booster.—An induction motor placed in series with an alternating current circuit so as to raise its pressure.

Induction Bridge.—An inductance bridge; a balance arranged in a manner similar to a Wheatstone bridge and used for measuring induction.

Induction Coil.—An induction coil is essentially a transformer with open magnetic circuit in which a pulsating direct current in the primary induces an alternating current of high voltage in the secondary. The primary usually consists of comparatively heavy insulated copper wire wound upon a core of annealed iron wire, and the secondary of fine wire is wound over the primary. Induction coils are used in X-ray work, wireless telegraphy, electrotherapy, internal combustion motor ignition, etc. Sometimes termed a spark coil.

Induction Factor.—In an alternating current circuit, the ratio between that element of the current which does no work and the total strength of the current.

Induction Flux.—The total number of lines of magnetic force in any part of a magnetic circuit.

Induction Frequency Converter.—A type of frequency converter consisting of an induction motor having a rotor driven at such speed that the secondary frequency has the desired value for the delivery circuit.

Induction Machine.—A machine for generating electricity for experimental purposes on the principle of electrostatic induction; also called *influence* machine. The Toepler-Holtz and Wimshurst machines are well known forms.

Induction Motor.—An alternating current motor which does not run synchronously, or in step, with the alternations; an *asynchronous motor.* The currents supplied are led through the field coils only, and the armature, not being connected to the external circuit, is rotated by currents induced by the varying field set up through the field coils, the rotating part is termed the *rotor*, and the stationary part the *stator*.

An induction motor should be run as near its normal primary electromotive force as possible, as the output and torque are directly proportional to the square of the primary pressure. An induction motor develops its greatest torque on starting, and its least when running in step with the rotating field. If it be overloaded, it will slow down until the induced currents in the armature are sufficient to carry the load.

Induction Multiphase Motor.—An induction motor driven by multiphase electric currents.

Induction Plates of Condenser.—The sheets of tin foil wherein electric charges are stored in an accumulator.

Induction Potential Regulator.—A form of stationary induction apparatus consisting of a coil in shunt and a coil in series, with the circuit so arranged that the ratio of transformation between them is

variable at will, and with the relative positions of the primary and secondary coils adjustable.

Induction Reactance.—The ohmic value of inductance in an electric circuit, as distinguished from the capacity reactance.

Induction Rotary.—A rotary transformer furnished with induced currents.

Induction Screen.—A metal screen interposed between two electrified or magnetic bodies in order to reduce the effect of induction.

Induction Telegraphy.—1. A method of telegraphy by which messages may be sent from railway trains while in motion; the principle of induction permitting communication of impulses from the car to a wire running parallel with the track.

2. Wireless telegraphy is a type of induction telegraphy.

Induction Top.—A copper disc caused to spin upon a vertical axis before the poles of a magnet to illustrate the influence of magnetic induction.

Induction Type Instrument.—Electric measuring instruments for alternating currents based upon the principle of a revolving magnetic field produced by two alternating currents that are out of phase.

Induction Wattmeter.—An electrical instrument for measuring the power delivered to a circuit. The operation of the induction type is similar to that of the induction motor, depending upon the action of a revolving or shifting magnetic field upon a magnetic body capable of rotation.

Inductive Capacity.—The quality of a dielectric substance by which it has the power of receiving and transmitting that electric strain called induction.

Inductive Circuit.—A circuit having inductance, but not capacity; *an induced circuit.*

Inductive Connection.—A connection between two circuits depending upon the property of induction solely, without any metallic contact whatever.

Inductive Disturbance.—A disturbance arising in telephone or telegraph circuits as the result of induction. Cross talk between telephone lines is an example of inductive disturbance; sometimes called *inductive interference.*

Inductive Electromotive Force.—An E. M. F. set up by induction.

Inductive Leak.—A leak having inductance, produced in an electric circuit.

Inductive Leakage.—Leakage effected in a circuit by the introduction of induction coils.

Inductive Load.—A load in which the current lags behind the voltage across the load.

Inductively Associated Circuit.—An electric circuit so related to another neighboring one that any action in it will be reflected in the other by a similar action, as the result of induction.

Inductive Pole.—An electric pole caused by induction.

Inductive Reactance. — Reactance resulting from self-induction.

Inductive Resistance.—A term sometimes applied to the *reactance*, which is the effect of self-induction in an alternating current circuit containing inductance. It is expressed in ohms.

Inductive Resistance Regulator.—A device for controlling the resistance in a circuit by regulating the inductance.

Inductive Retardation.—A lagging in the rate of transmission of an electric signal due to induction in the circuit.

Inductivity.—Inductive quality; the power or capacity for induction.

Inductize.—To exert electric induction upon a body or circuit.

Inductometer.—An instrument for measuring the inductance of a circuit.

Inductophone.—An invention for picking up telegraphic messages from moving railroad trains by induction between a circuit on the train and coils along the line, in which a telephone receiver takes the place of a sounder.

Inductor.—1. That part of a generator or magneto that furnishes the magnetic field.

In a dynamo the inductor is an electromagnet, in a magneto it is a permanent artificial magnet.

2. A heavy mass of soft iron, laminated to avoid eddy currents, which is carried on the rotor of an inductor generator to increase the number of lines of force issuing from the poles of the stator.

Inductor Alternator.—An alternating current generator in which both armature and field coils are stationary. A moving mass of laminated iron, having projections called inductors, is employed to cause the magnetic flux from the magnet to pass through the stationary coils. The field frame has internal projections corresponding to the inductors, and these constitute the cores of the armature coils.

Inductor Generator.—A form of dynamo in which both the armature coils and field magnet coils are stationary, the cutting by the armature conductor of the lines of force set up by the field magnets being effected by masses of iron moving past the field magnet poles.

Inductorium.—A name sometimes given to the *induction coil.*

Inductors of Electrostatic Machine.—The parts of a Holtz electric machine which receive the original charges. They consist of four tin foil discs connected in pairs by strips of tin foil and covered with paper.

Inductric Body.—The body possessing the original charge which produces induction in another body.

Inductroscope.—Any device for showing the existence of induction between electric circuits.

Inelastic.—Rigid, inflexible; unable to return or assume its original condition or shape, after a strain. In a scientific sense, all bodies possess elasticity, its amount or degree alone varying.

Inertia.—That property of matter by virtue of which it cannot of itself change its own state of rest or of motion.

Inertia, Electric.—A term sometimes used for self-inductance. When a circuit has self-inductance, the current will continue to flow for a short time after the circuit is broken, as in ignition for gas engines, a spark is produced when the current is interrupted. It takes therefore, both time and resistance to stop the flow of the current, the same as is required to bring a moving material body to rest. Hence, the application of the term "inertia."

Inferred Zero.—A zero upon a scale of measurement assumed for convenience in making calculations, though actually too remote to be arrived at.

Infinity Plug.—A plug in a resistance box, seated between two brass plates not otherwise connected, so that when it is withdrawn the circuit is opened and made of, so-called, infinite resistance.

Inflexible Conduit.—An underground conduit system so built that it will not admit of access to its conductors after it is once laid; *a solid conduit.*

Influence.—A term sometimes used for electrostatic induction.

Influence Charge.—An electric charge obtained by electrostatic induction.

Influence Machine.—An *induction* machine for generating electricity for experimental purposes on the principle of electrostatic induction. It depends upon the use of a small initial charge which acting by influence induces other charges which are conveyed by the moving parts of the machine to some point where they may serve to intensify the initial charge, or be drawn off by a suitable collector. The *electrophorus* is the simplest and earliest form, and its best known developments are the Wimshurst machine and the Toepler-Holtz machine.

Infra-red Light.—Radiation having greater wave lengths than the red rays of the spectrum.

Infra-red Spectrum.—The invisible rays of a spectrum which are below the red, *i. e.*, those which have a greater wave length than the visible red rays. They have a slower rate of vibration than 400 billion per second.

Ingot.—1. An oblong block into which such metals as gold, silver, copper, tin or alloys, are cast after purification. Such blocks usually bear the finer's or foundry stamp and are ready for remelting.

2. A slightly conical, hexagonal or cylindrical mass into which steel is cast before it is forged or rolled. The ingot moulds are usually of cast iron, of great thickness and accurately fitted. After pouring, as soon as the steel is set, the cotters are knocked out of the mould, and the red hot mass taken by the crane from the mould and placed in the soaking pits to anneal or reheat.

Ingot Steel.—A term applied to mild steel produced by the Bessemer or open hearth process, as it is cast into the form of ingots, preparatory to further treatment.

Ingredient.—That which enters into a compound, or is a component part of any compound or mixture; an element.

Inherent Regulation.—An electric generator may be required to deliver at a certain speed, an E. M. F. which is within a specified percentage of a constant value when the load is varied. This is called its *regulation*, and when the E. M. F. is regulated by the machine without the aid of auxiliary devices the act is known as *inherent regulation*.

Initial.—Pertaining to a beginning; existing at or constituting a beginning.

Initial Magnetization. — Magnetization produced at the beginning of a process or action.

Initial Velocity.—The speed with which an object is originally endowed, or the velocity at which it is already moving, when modifying forces begin to act upon it.

Injection.—1. In construction, the saturation of telegraph poles with a preservative preparation to prevent decay; impregnation.

2. In steam engineering, a term applied to the admission of cooling water to a jet condenser.

Injector.—1. An apparatus by which a condenser or similar instrument may be temporarily inserted in an electric circuit.

2. A boiler feeding device, in which the momentum of a steam jet, directed by a series of suitably disposed conical nozzles, carries a stream of water into the boiler; the steam condensing within and heating the water which it forces along. The action of an injector is due to the fact that the velocity of a jet of steam flowing from a nozzle is much greater than water flowing under the same conditions. Although the injector has an almost perfect efficiency as a boiler feeder, it is not the most economical, since it can draw only moderately warm water, while a pump can feed water which has been heated by exhaust steam which otherwise would be wasted.

Inkless Recorder.—A recorder for electric measuring instruments which does away with the usual pen, employing instead a sharp steel point which is forced against the paper every few seconds by means of an electromagnet actuated by the driving clock. Thus, a series of dots or indentations is registered upon the chart.

Ink Writer.—In telegraphy, a recording register employed wherever a permanent record of messages is desirable. A compact case of brass and glass encloses the clock work mechanism. When a current is flowing, the armature lever carrying the paper strip with it, moves up against a disc which is kept moist with ink from an ink roller; when the current ceases a spring draws the lever and paper away from the printing wheel as the disc is called. In this way dots and dashes are recorded on the strip according to the duration of the contacts between the paper and the wheel.

In Line.—A shop term, to signify that the work is in the same center or in the same plane. To get several distant points in line, measurement is taken from a known level surface.

Inners.—The inner set of springs in the spring jack of a telephone switchboard.

Input.—The intake or energy absorbed by a machine during its operation, as distinguished from the output of useful energy delivered by it.

Input of Dynamo.—The mechanical energy absorbed by a dynamo for its operation.

Insertion.—In mechanics, sheets of elastic material used to make joints between flanges of pipes, etc., consisting usually of india rubber, with canvas or duck inserted.

Inside Admission.—In a steam engine, a reversal of the usual methods generally followed with piston valves, in admitting steam through the central cavity on the cylinder face, the lap being provided on the inner edges of the valve, while steam is exhausted past the outer edges into the valve chest. This prevents high pressure steam from coming into contact with the valve spindle glands, and materially shortens the steam passage from a high pressure to its intermediate cylinder.

Inside Box Brush.—A form of brush suitable for polishing the inner surfaces of metallic bodies preparatory to electroplating.

Inside Wiring.—A system of electric wiring installed inside a building for lighting or other purposes.

Inspection Boxes.—Boxes provided in a system of electric mains, having manholes to allow of inspection and repairs.

Inspirator.—A lifting and forcing injector, in which two distinct sets of steam and water cones are combined within one body, one set for lifting and one for forcing; a double tube injector.

Installation.—1. The act of setting up an apparatus or erecting a plant for some special work.

2. The buildings, apparatus and accessories forming the entire plant.

Installation, Electric.—1. The act of erecting an electric plant or system.

2. An electric plant or system.

Instantaneous Contact Method.—A method of ascertaining the form of the wave in an alternating current by contacts made at certain instants during each period of alternation.

Instantaneous Current.—The strength of an electric current existing in a circuit at a given instant.

Instantaneous Efficiency of Transformer.—The efficiency of a transformer at a given instant.

Instantaneous Electromotive Force.—The E. M. F. in a circuit at a given instant.

Instantaneous Pressure.—The instantaneous electromotive force.

Instantaneous Value.—1. A value taken at a given instant, and useful for that instant only, as distinguished from a value averaged for a length of time.

2. In an alternating current, the value of the wave taken at any point in the wave.

Instrument.—That by which work is performed, or anything is effected; a tool; a utensil; an implement; as, the instruments of a mechanic, astronomical instruments, and the like.

Instrument Zero.—The true zero upon the scale of a measuring instrument, as distinguished from a false zero arbitrarily chosen; *the scale zero.*

Insulate.—To safeguard a body against the escape of electricity from it, or the conduction of electricity to it.

Insulated Body.—A body safeguarded by insulation against escape of electricity either to or from it.

Insulated Conductors.—Wires for conducting electricity protected by a covering of insulating material.

Insulated Pliers—Pliers provided with handles of non-conducting material.

Insulated Trolley Crossing.—A device placed at a point where trolley wires cross, and so insulated as to prevent electrical contact of the wires.

Insulated Turnbuckle.—A device, properly insulated, for tightening the wires on overhead circuits.

Insulated Wires.—Wires covered with insulating material.

Insulating Bushing.—A bushing for an incandescent lamp socket made of non-conducting material.

Insulating Cements.—Adhesive compounds which not only cement bodies together, but at the same time serve as electric insulators between them.

Insulating Coating or Covering.—A surface layer of any non-conducting material.

Insulating Gloves.—Rubber gloves used to enable linemen and repairmen to handle live wires without danger of shock.

Insulating Joint.—A coupling which also serves as an insulator between the bodies joined.

Insulating Materials.—Non-conductors; substances such as glass, sealing wax, silk, shellac, india rubber, resin and various compounds, which do not conduct electricity.

There is no perfect insulating material. Gases are almost perfect insulators, though a gas at low pressures may convey electricity freely. The specific resistance of some important insulating materials at ordinary temperatures is as follows:

Mica	8.4×10^7	megohms
Glass	9×10^7	"
Gutta percha	4.5×10^8	"
Shellac	9×10^9	"
Ebonite	2.8×10^{10}	"
Paraffin wax	3.4×10^{10}	"

Insulating Paint.—A paint that is unaffected by an electric current; it is made of fossil gum, a pigment, and a vehicle, usually spirit of naphtha.

Insulating Paper.—A paper used largely in covering steam pipes and steam surfaces

to prevent the loss of heat, or on woodwork to protect it; also to prevent air currents through the walls of buildings.

Insulating Sleeve.—A sleeve joint of non-conducting material for splicing two ends of insulated wire.

Insulating Stool.—A stool having legs of glass, or other insulating material to serve in experiments to cut off electrical connection with the earth.

Insulating Tape.—Tape, usually adhesive, rendered non-conducting by being saturated with an insulating compound, for the purpose of covering stripped ends and other exposed parts of insulated electric conductors.

Insulating Tube.—1. An insulating sleeve.

2. A non-conducting tube designed to protect an insulated wire at the point where it runs through a partition or wall.

Insulating Varnish.—A prepared varnish for insulating surfaces of electrical appliances.

Insulating Washer.—A washer made of non-conducting material.

Insulation.—1. The condition of a conducting body when insulated by the interposition of non-conductors to prevent the escape of electricity.

The substances that will not conduct the electrical current, but interfere with its transmission are: oils, porcelain, wool, silk, resin, gutta percha, shellac, ebonite, paraffin, glass. On account of this property they are extensively used in all the branches of electrical industry where it is desirable to confine the current to definite limits. They are thus called "insulators" (Latin, *insula*, an island; *insulatus*, made into an island.) The insulation of the electric current is, of course, not absolute: rather is it correct to say that the resistance of insulators is so great that the leakage through them is practically negligible. Thus, while certain poor conductors offer a high resistance to current, glass, at 20° Centigrade, offers a resistance of 91,000,000 megohms (millions of ohms) per cubic centimeter; the gutta percha, 450,000,000 megohms; hard rubber, or ebonite, 28,000,000,000 megohms, and paraffin, 34,000,-000,000 megohms.

Insulation Bracket.—An insulator bracket made of non-conducting material.

Insulation Breakown.—Any serious defect in the insulation of electric apparatus.

Insulation, Electric. — Non-conducting material so related to electrical appliances as to prevent leakage of electricity.

Insulation Lightning Protector.—A device for protecting electrical apparatus from lightning by preventing the discharge from attacking the coils and injuring the insulation.

Insulation Resistance.—The ohmic resistance in an electric circuit offered by an insulating coating, cover, material or support to an impressed voltage, tending to produce a leakage of current through the same. By testing this resistance, a ready means is afforded of locating a fault in the insulation.

Insulation Test.—The object of this test is to ascertain whether the insulation of a circuit or of the wire wound upon a metal spool or core, such as a magnet core, has broken down or is still in good order. In making the test, one terminal of a battery is connected to a galvanometer terminal. The unconnected terminal of the battery is connected to one end of the coil under test, the other end of the coil remaining free and unconnected. Some portion of the metal core, say the end, is then cleaned bright with a knife or emery cloth, and the unconnected terminal of the galvanometer is brought into contact with this bright or clean part of the core. If then some portion of the insulation of the wire has been abraded or destroyed, thus bringing the bare wire into contact with the metal core, the needle of the galvanometer will be deflected since a closed circuit is formed through the core and wire. If on the contrary the insulation is perfect, the needle will be undeflected.

It will thus be seen that in the conductivity test it is necessary that the needle should be deflected, or turned, to prove that all is right; while in the insulation test the converse holds good, if the needle is deflected it proves that the insulation is broken down.

Insulator.—1. A non-conductor.

2. A contrivance usually made of glass or porcelain for supporting telegraph wires and at the same time preventing escape of current.

Insulator Bracket.—A simple wood or metal bracket for supporting one or more insulators for overhead wiring.

Insulator Cap.—A cover or hood, usually of iron, set over, and a little above, an insulator to protect it from injury.

Insulator Pin.—A wooden pin attached to pole cross arms or brackets, upon which the insulators are screwed.

Intaglio.—An electro or die with the engraved parts sunk, or hollowed out, beneath the surface; an incised carving, as distinguished from a carving in relief.

Intake.—1. In a waterworks, the pipe by means of which water is drawn off from a

well or other source into a receiving reservoir, standpipe or main.

2. In an internal combustion engine, the inlet pipe between the *carburetter* and the cylinder which conducts the mixture to the cylinder.

Intake Wires.—Wires leading into a distributing box.

Integrating Meter.—A meter provided with a clock which operates a counting device through an intermediate gearing driven by the current.

Integrating Wattmeter.—A watt hour meter; a wattmeter which records upon its dial the total number of watthours of electric energy consumed by a customer to whom electric power is supplied; a form of recording wattmeter.

Integrator.—A device which automatically counts or adds up items of calculation or measurement.

Intensifier.—In hydraulics, a device frequently employed in place of the hydraulic accumulator, for converting a low pressure into a higher. The water at low pressure operates a piston in a large cylinder, which in turn operates a ram of smaller diameter in a smaller cylinder. The areas of the two cylinders are proportional to the difference in the low and high pressure required.

Intensity.—The degree of energy with which a force acts, measured in suitable units.

Intensity Armature.—A term now rarely used, but formerly applied to an armature wound for a high resistance.

Intensity Current.—A term no longer in use, but formerly applied to a current due to a high electromotive force.

Intensity of Current.—The strength of an electric current. It is the quantity of electricity that flows past any point in a circuit in one second, and is measured by a unit called the *ampere*. The intensity of a current has to do only with the amperage and must be considered apart from the pressure or voltage.

Intensity of Earth's Magnetism.—The strength of the earth's magnetic force at different points on the earth's surface. It varies slightly each day and at different times during the year, and occasionally sudden changes occur due to conditions known as magnetic storms.

Intensity of Field.—The strength of the force in a magnetic field as measured by its action upon a unit pole placed at any point in the field.

Intensity of Illumination.—The quantity of light that falls upon a unit surface. It is inversely proportional to the square of the distance from the source of light.

Intensity of Light.—The degree of illuminating power possessed by a source of light.

Intensity of Magnetic Field.—The force with which a magnetic field acts upon a unit magnetic pole; its unit is that intensity of field which acts with unit force upon a unit pole.

Intensity of Magnetic Flux.—The strength of the force in a magnetic field.

Intensity of Magnetization.—The degree to which a magnet is magnetized; the quotient of the *magnetic moment* of a magnet divided by its volume.

Intensity of Radiation.—The ratio of the degree of radiation from a surface, and the extent of surface which gives off the radiation.

Inter-atomic Ether.—The ether which is conceived to exist between the atoms which form the molecules of material substances.

Intercommunicating Telephone System.—An arrangement of a telephone system having a switchboard at every station. The general plan of wiring a number of telephone outfits so that each one has its own wire, forming a circuit between itself and any other by using a common return wire as the other limb, is adapted primarily to the needs of manufactories, business houses having a number of separate offices or desks, and to small domestic systems. Such small systems require no central office nor any scheme of selective signaling. Moreover, the danger of being "listened in" is reduced to a minimum, if not rendered impossible; and the expense and trouble of caring for the apparatus is similarly reduced by using a common calling battery.

Inter-connected Armature Winding.—An armature winding in which the coils are connected to corresponding segments of the commutator; *cross connected.*

Inter-crossing.—The cross system of running overhead wires to counteract the tendency to induction, in which the wires are crossed at intervals so as to change their relations to one another.

Inter-exchange Working.—Telephone working, through more than one exchange.

Interference of Electromagnetic Waves.—The mutual destruction of simultaneous electromagnetic waves which agree in period and amplitude but are opposite in phase; an effect corresponding to that of the interference of light and sound waves.

Inter-ferric Gap or Space.—The air gap in a magnetic circuit between iron faces.

Interflange.—The distance between the flanges of a spool or bobbin, being the available space upon which the wire may be wound.

Interheater.—In a steam engine, an apparatus acting as an intermediate receiver between the high and low pressure cylinders. The interheater is traversed by tubes carrying high pressure steam, which slightly superheats the exhaust from the high pressure, preventing initial condensation in the low pressure engine. Also called *superheating receiver.*

Interior Conduit.—A conduit suitable for use in the walls or floors of a building for the accommodation of electric wires.

Interior Conduit Junction Box.—In an indoor distribution system, a box or casing in which connections are made with the mains.

Interior Pole Dynamo.—A dynamo in which the armature revolves around outside of the fields.

Inter-linked Polyphase System.—A system of polyphase currents in which one wire may act as return for another, instead of having each phase supplied with separate conductors throughout.

Inter-linked Two Phase System.—In polyphase alternating current transmission, a system in which, by joining any two conductors of a four wire system, a common return is made for the two circuits; the *two phase three wire system.*

Interlocking Apparatus.—A system of interlocking levers by which railway switches and signals are operated from a tower, such that when the track has been properly set and the signal shown, it becomes impossible to clear another route that would interfere with the one already set.

Interlocking Electromagnet.—An electromagnet with interlocking armatures employed at railway crossings, whereby an approaching train rings a signal which automatically ceases when the train has passed.

Intermediate Cable.—A variety of submarine cable intermediate between the types used in deep water and at the shore-end.

Intermediate Distributing Board.—In a telephone exchange, a secondary distributing board employed in connection with a multiple switchboard, so that any answering jack and drop may be connected to any operator's position.

Intermediate Station.—Any telegraph or telephone station which is not a terminal.

Intermediate Switch.—A switch which enables an intermediate telephone station to communicate with a terminal without interfering with the line.

Intermittent.—Acting at intervals, or without uniform continuity.

Intermittent Contact.—Contact between overhead wires which sometimes takes place as the result of swinging against each other, or from the effects of temperature changes.

Intermittent Cross.—A swinging cross; an intermittent contact between overhead wires due to swinging or other occasional cause.

Intermittent Current.—An electric current that flows at intervals only, so that at alternate intervals the circuit is free from electricity.

Intermittent Disconnection.—A fault which occurs intermittently in a line or circuit.

Intermittent Earth.—A swinging earth; an intermittent contact with the earth caused by swinging or other occasional influence.

Intermittent Electromotive Force.—An electromotive force which has intermittent instead of uniform action.

Intermittent Integrating Meter.—An integrating meter which does not continuously compute the use of energy, but sums it up at definite intervals.

Intermitter.—A name sometimes given to a contact breaker or interrupter, a device for automatically making and breaking an electric circuit.

Inter-molecular.—Between, or among the molecules of matter.

Inter-molecular Ether.—The ether which is conceived to exist between the molecules of matter; the interatomic ether.

Internal Armature Generator.—A dynamo having its armature within the pole pieces, as distinguished from an *external* armature generator.

Internal Characteristic.—The characteristic curve of a shunt wound dynamo on open circuit, the shunt circuit being active.

Internal Circuit.—The portion of a circuit included within the generator.

Internal Combustion Engine.—A heat engine deriving its power from the energy liberated by the explosion of a mixture of some hydrocarbon ignited, usually, by an electric spark. The fuel is received in the engine cylinder in a gaseous or vaporized form, mixed with atmospheric air. The combustion of the mixture evolves great heat, dilates the gases, and so creates pressure which is applied to a piston as in a steam engine.

Internal Magnetic Circuit.—That portion of a magnetic circuit included within the core of the magnet.

Internal Magnetic Field.—That portion of a magnetic field included within the core of the magnet.

Internal Polarization.—A polarization which takes place in living organic tissues when a strong electric current is passed through them.

Internal Poles of Dynamo.—The poles of the electromagnetic field of a dynamo.

Internal Pressure.—In a steam boiler, the force with which the confined steam presses against the boiler walls which produces a tensile stress in the shell. In the circumferential direction, this stress, per square inch of metal, is equal to one-half the diameter of the shell multiplied by the pressure in pounds per square inch. The intensity of longitudinal stress is only half as great as that in the circumferential direction. In a *spherical* shell the stress is only half as great as in a *cylindrical* shell, taken under similar conditions of diameter, thickness and pressure.

Internal Resistance.—A resistance found in an electric source itself; an element which bears an important relation to the external resistance of the circuit.

Internal Resistance of Cell.—An interference with the flow of electric current which takes place in a primary cell due to resistance within the cell, depending upon its size, shape and material.

International Ampere.—The legal value of the ampere as fixed by the International Congress of Electricians, held at Chicago in 1893; one tenth of the unit of current of the C. G. S. system of electromagnetic units, represented as the uniform current which deposits silver at the rate of 0.001118 grams per second from a solution of given fixed strength of nitrate of silver in water.

International Candle.—A photometric unit established by agreement between authorities in Great Britain, France and America in 1909, and to be approved by other countries. The new unit is 1.6 per cent. less than the candle hitherto standard in the U. S. The international candle, as it is to be known, now equals 1 pentane, 1 bougie decimale, 1 American candle, 1.11 Hefner unit, 0.104 Carcel unit.

International Coulomb.—The legal value of the coulomb as fixed by the International Congress of Electricians, held at Chicago in 1893; the amount of electricity borne past a given point by a current of one international ampere in one second of time.

International Farad.—The legal value of the farad as fixed by the International Congress of Electricians, held at Chicago in 1893; the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity.

International Henry.—The legal value of the henry as fixed by the International Congress of Electricians, held at Chicago in 1893; the induction in a circuit when the electromotive force induced in the circuit is one international volt, while the inducing

current varies at the rate of one ampere per second.

International Joule.—The legal value of the joule as fixed by the International Congress of Electricians, held at Chicago in 1893; a value equal to 10 units of work in the C. G. S. system, represented by the energy expended in one second by an international ampere in an international ohm.

International Morse Code.—A name sometimes given to the telegraphic alphabet used in Europe and elsewhere, to distinguish it from the American Morse code.

International Ohm.—The legal value of the ohm as fixed by the International Congress of Electricians, held at Chicago in 1893; a value equal to 10^9 units of resistance of the C. G S. system of electromagnetic units, and represented by the resistance offered to a uniform current by a column of pure mercury which is 106 3 centimeters long, of uniform cross section, containing 14.4521 grams of mercury, and at the temperature of melting ice.

International Volt.—The legal value of the volt as fixed by the International Congress of Electricians, held at Chicago in 1893; the electromotive force that, applied to a conductor having a resistance of one international ohm, will produce a current of one international ampere, and represented by $\frac{1000}{1434}$ of the E. M. F. between the poles of the voltaic cell, known as Clark's cell, at a temperature of 15° C., prepared according to specification.

International Watt.—The legal value of the watt as fixed by the International Congress of Electricians, held at Chicago in 1893; a value equal to 10^7 units of power in the C. G. S. system, and represented as the work done at the rate of one joule per second.

Interpolar Gap or Space.—The air space between the pole pieces of a dynamo or motor.

Interpole.—A small auxiliary pole introduced between two main field poles of a motor or dynamo in order to produce a compensating field under heavy loads; a compensating or commutating pole.

Interpole Dynamo.—A direct current dynamo, especially one driven by a steam turbine, provided with auxiliary poles between the main field poles, thereby constituting a compensating field which serves to reduce the sparking due to high frequency of commutation.

Interpole Motor.—A shunt, compound or series motor which has, between the regular field poles, smaller ones with coils carrying all or part of the line current, for the purpose of producing a reversing field for the coil undergoing commutation Interpole motors spark less than other types under heavy loads, and hence motors can be designed with interpoles to carry much higher E. M F. than before; a *commutating* or *compensating pole motor*.

Interrupted.—Broken in upon; having the continuity of the current broken; as, by a *contact breaker*.

Interrupted Current System.—A method of electric distribution by continuous currents broken at regular intervals.

Interrupter.—1. A device for opening and closing an electric circuit, in which a vibrating spring or similar arrangement makes and breaks a circuit at rapid intervals.

2. On an ignition magneto, a device for breaking the primary circuit at the time a spark is required.

Intersection.—1. The act of cutting or crossing; as, two lines meeting in the same plane.

2. The point where two lines cut or cross each other.

Interstice.—That which intervenes between one thing and another; especially, an empty space between things closely set, or the parts which compose a body; a hole; an interval.

Interurban Communication.—Communication by telegraph or telephone between neighboring towns.

Interurban Electric Railway.—An electric railway connecting neighboring towns.

Interurban Telephony.—Telephone communication between neighboring towns.

Intorsion.—A winding, bending or twisting; as, in electric wiring.

Intra-molecular.—Within the body of a molecule.

Intra-polar Electrolysis.—The electrolysis which occurs immediately between electrodes, apart from that which takes place about them.

Intrinsic Brilliancy.—The intensity of the light per unit area of the luminous source.

Intrinsic Brilliancy of Crater.—The total quantity of light emitted by an electric arc is the product of the intrinsic brilliancy multiplied by the area of the crater. From experiments of M. Violle, it appears that the intrinsic brilliancy of the crater remains constant when the power supplied is raised through a considerable range. The intrinsic brilliancy of a fully developed arc has been estimated at 190 candle power per square millimeter of crater area.

Intrinsic Electrization.—Electrification of a body due to natural causes inherent in the substance.

Intrinsic Intensity of Light.—The amount of light given by a luminous source per unit area.

Intrinsic Magnetization.—Impressed magnetization, as distinguished from that caused by electric currents.

Invariable Calibration.—A calibration for preserving constant the intensity of a galvanometer field, notwithstanding the proximity of masses of iron.

Inverse.—Opposite in order; reversed; opposed to direct.

Inverse Current.—1. The make induced current; the current set up by self-induction when a circuit is closed.

2. The current produced by induction in the secondary coil of a transformer when the circuit of the primary is closed.

Inverse Electromotive Force.—An electromotive force acting in an opposite direction to the prevailing electromotive force in a circuit.

Inverse Ratio.—That formed by inverting the terms of a given ratio; thus, 8 : 9 is the inverse of 9 : 8.

Inverse Square Law.—Electric forces and various other physical phenomena are observed to decrease in intensity as the point of application recedes from the point or source from which the effect proceeds. If the intensity of a force, as, for instance, magnetic attraction, at a given point be f, and the distance of the point from the source of the force be r, the law may be expressed in an equation as follows:

$$f = \frac{k}{r^2}$$

in which k is a constant.

Inversion, Electric.—A method by which, when the solution of a problem in electro-statics has been obtained, it is possible by a geometrical process to obtain the solution of another.

Inversion of Images.—In electrostatics, the application of the mathematical theory of inversion in the solution of problems. When any one problem is solved, the solution of another may be deduced by a purely geometrical process.

Inverted Arch.—An arch whose crown is turned downwards, the keystone thus being its lowest point. It is used in foundations, in the floors of tunnels, etc., where it is necessary to sustain great pressure. An inverted arch is employed underneath large openings in the walls of buildings, to prevent deformation of the pillars under the side thrust.

Inverted Arc Lamp.—An arc lamp in which the negative carbon is above the positive instead of being below it, as is usually the case.

Inverted Converter.—A name sometimes given to a rotary converter for changing direct currents into alternating currents.

Inverted Dynamo.—An under-type dynamo; a dynamo in which the armature is placed below the field coils and yoke in order to secure greater stability and freedom from vibration.

Inverted Rotary Converter.—A name sometimes given to a converter that is run as a direct current motor for supplying an alternating current. When so run, the speed increases when the field becomes weak, and lessens when the fields strengthen, but the ratio to each other of the direct and alternating electromotive force remains unchanged.

Inverted Syphon.—In hydraulics, a conduit, shaped like a gigantic U, by means of which water mains are carried underneath rivers, etc., the water rising as high on the further shore as on the other, owing to a fundamental principle of hydrostatics.

Invert Insulator.—A line insulator set inverted.

Invisible Electric Contact Matting.—A floor covering supplied with concealed electric contacts which close the circuit of an alarm when a person treads upon them.

Invisible Spectrum.—The *infra-red* rays at one end of the spectrum and the *ultra-violet* rays at the other, which cannot be perceived by the eye.

Inward Flow Turbine.—In hydraulics, a water motor consisting essentially of two horizontal rings of buckets, one ring being enclosed within the other, and its buckets or *chutes* becoming the guides to a column of water, which having descended by gravity under a definite head, is caused to impinge on the buckets of the inner ring and to turn it by reaction.

Ionic Attraction.—The attraction between *anions* and *cations*.

Ionic Conductivities.—The conductivities of ions, which, in proper combinations, give molecular conductivities of an electrolyte.

Ionization.—1. The breaking up of a compound, as an electrolyte, into positive and negative ions.

2. As applied to *gases*, which have free ions in small numbers, it is the breaking up of atoms into positive and negative ions by the application of proper external energy, thus producing electric conductivity in gases.

Ions.—1. The products of electrolysis which appear at the electrodes; the component which appears at the anode is called the *anion*, or electro-negative component, and that which appears at the cathode is called the *cation* or electro-positive component.

2. In *gases*, the elements to which and to whose motion, under the action of electric forces, is supposed to be due their electric conductivity.

I^2R Activity.—The electric activity wasted in heating the conductor, caused by the opposition offered to the flow of the current by the mass of the conductor; the C^2R activity. *It is equal to the square of the current strength multiplied by the resistance.*

Iridescence.—An effect of the interference of light upon certain surfaces, exhibiting intermingling colors, as of the rainbow.

Iridium Lamp.—An incandescent lamp employing, for filament material, the rare metal, iridium, in the form of a powder mixed with a binding medium and squirted into threads. The low voltage of this lamp and the scarcity of iridium prevent the commercial success of this type.

I^2R Loss.—The loss in an electric circuit due to the resistance. It is computed as equal to the square of the current I^2 multiplied by the resistance.

Iron.—One of the metallic elements. Of all metals, none plays so important a part in civilization, mechanical advance, etc., as iron; it is obtained from ores in which it is combined with earthy or stony substances and frequently with carbon, phosphorus, sulphur, arsenic, magnesia, etc.; iron is never found in its native condition, chemically pure, nor is any iron manufactured in a large way found to be free from impurities. Iron is put upon the market in four forms: (1) cast iron; (2) malleable; (3) wrought iron; (4) steel. Different names are given to iron as needed to describe its size, form, quality or use, thus: gossamer iron (sponge iron), hoop, band, scroll, tee, groove, plate, bar, angle, flat, rod, sheet, hexagon, galvanized, horse shoe, railroad and scrap iron.

Iron Armored Conduit.—A conduit for electric wiring which is protected by an outside casing of iron.

Iron Cement.—In steam engineering, the material used for making *rust joints*. It consists of iron borings, passed through a ⅛ or ¼ sieve, mixed with sal ammoniac and dampened. Sulphur is usually added.

Iron-clad.—Covered with, or clad in iron.

Iron-clad Armature.—An armature which has its windings sunk into deep channels or grooves in the surface of its core.

Iron-clad Drop.—An annunciator having an iron-clad electromagnet.

Iron-clad Dynamo.—1. A dynamo having an iron-clad armature.

2. A dynamo in which the iron of the field magnet encloses both the magnet coils and the armature.

Iron-clad Electromagnet.—A type of electromagnet designed to offer powerful attraction through a short distance; it consists of a short cylindrical electromagnet with an outer tube united to the iron core at the bottom; *a tubular electromagnet.*

Iron-clad Inductance.—Inductance pertaining to an iron magnetic circuit.

Iron-clad Motor.—A motor provided with an iron-clad armature.

Iron-clad Rheostat.—A resistance box having its insulated coils sunk into a mass of iron.

Iron Core.—The mass of iron forming the central portion of an electromagnet or armature around which the coils are wound.

Iron Core Loss.—The electric losses occurring in armatures and transformers due to hysteresis and eddy currents in the iron of the core.

Iron Covered Cable.—A submarine cable sheathed with iron.

Iron Enclosed Electromagnet.—An iron-clad electromagnet.

Iron Loss in Transformer.—The electrical loss in a transformer due to hysteresis and eddy currents in its masses of iron. The amount of loss due to eddy or Foucault currents is uncertain but it may be minimized by laminating the core. The quality of the iron and value of the magnetic induction are factors upon which the hysteresis loss depends The work lost during each complete magnetic cycle, is, according to Steinmetz, expressed by the following equation:

$$W = hB^{1.6}$$

in which, B = the induction; h being a coefficient depending on the nature of the iron and the unit of mass chosen.

Iron Magnetic Circuit.—A term sometimes applied to a magnetic circuit completed wholly within iron; a ferric magnetic circuit.

Iron Pyrites.—A natural metallic sulphide of iron, utilized in the manufacture of sulphuric acid, sulphate of iron and alum. It is sometimes mistaken for gold, but may be distinguished by its hardness and brittleness.

Iron Reluctance.—Magnetic resistance due to the iron present in a magnetic circuit.

Iron Wire.—Iron has been extensively used for electrical conductors, especially in telegraph and telephone circuits, but it is so rarely free from alloying materials that only the best product can be used for this purpose. Iron from Norway, Sweden and Russia is superior to domestic iron because of the precise refining methods employed in those countries. The electrical resistance of pure iron wire is 5.95 times that of equivalent copper wire. Iron wire is only employed after having received a coating of zinc by the process of galvanizing to prevent rust.

Iron Work Fault.—A fault which may occur in a dynamo due to the grounding of its circuit through its iron frame.

Irreciprocal Conduction.—Electrical conduction in which the current suffers a change by a reversal of direction.

Irregular Magnetic Flux.—A converging or diverging magnetic flux.

Irregular Variations.—Variations of the magnetic needle occurring irregularly.

Irreversible Cycles.—A substance is said to pass through a cycle of operations, when its volume, pressure and temperature, are altered in such a way, that after a series of changes it returns to its original state. When these series of changes can take place in one way only, the cycle is said to be irreversible.

Irreversible Heat Effect.—The heat produced by an electric current in a homogeneous conductor; it is the same regardless of the direction of the current; also called the *Joule effect.*

Irritability, Electric.—The tendency to irritation of animal tissues when exposed to an electric current or discharge.

Irrotational Stress.—Stress devoid of rotation.

I Section.—In building, a rolled I beam.

Isobaric Surface.—A surface in the air, all points of which have the same barometrical pressure.

Isobars.—Lines drawn upon a map or chart connecting places on the earth's surface in which the barometric pressure is the same; also called *isobaric* or *isobarometric lines.*

Isochasmic Curves.—Lines drawn upon a map bounding zones of the earth's surface which have the same annual number of auroras.

Isochromatic.—Of the same color or tint; of uniform color throughout.

Isochronism.—The property of performing oscillations in equal spaces of time.

Isochronize.—To cause to vibrate in equal spaces of time.

Isochronous.—A term applied to two or more different motions which occur in the same time, or having equal times.

Isochronous Governor.—A governor which is very steady at one fixed speed, but which requires only a slight variation in speed to make the arms fly up or down, according as the speed increases or lessens This is effected by placing a cross piece upon the governor spindle, the two ball arms being hinged to this piece in a crosswise manner, so that the ball is on the opposite side of the spindle to its pin. Care needs to be taken in designing such a governor that it is not over-sensitive.

Isochronous Oscillations or Vibrations.—Vibrations, as of a pendulum, performed in equal times.

Isoclinal, or Isoclinic.—Having equal magnetic inclination or dip.

Isoclinic Lines.—Lines drawn upon a map passing through points upon the earth's surface which have the same magnetic inclination or dip.

Isodynamic Lines.—Lines drawn upon a map passing through the points on the earth's surface which have the same horizontal magnetic intensity.

Isodynamic Map.—A map upon which is drawn a system of isodynamic lines.

Isoelectric Points.—In electro-therapeutics, points which have equal potential.

Isogonic Lines.—Lines drawn upon a map passing through points on the earth's surface which have the same magnetic declination.

Isogonic Map.—A map upon which is drawn a system of isogonic lines; *a variation map.*

Isolated Electric Lighting.—Electric lighting by means of an installation situated on the premises, and not depending upon a general distributing station.

Isolated Plant.—An electric installation situated upon the premises where the power is to be utilized.

Isolated Station Switchboard.—A telephone switchboard for a sub-station, or for private use.

Isolating Switch.—A switch whereby an electric lamp may be cut out of a circuit without affecting the other lamps on that circuit.

Isolux.—A line drawn through points of equal illumination upon a lighted surface.

Isomerism.—Identity of composition and molecular weight in substances which differ in physical or chemical properties, or both.

Isometric Projection.—A method of perspective drawing, employed in delineating mechanical objects. It enables three sides to be seen at one view, being a projection on lines equally inclined to the three principal axes of the object delineated, the angles remaining the same as in plane drawing.

Isothermal Expansion.—Takes place when a gas expands while its temperature remains constant, heat being added. The opposite of isothermal compression. The volume of a perfect gas, according to Mariotte's law, varies inversely as its pressure when the temperature is kept constant. The curve constructed from this law is called the isothermal curve, or curve of equal temperatures and is the common or rectangular hyperbola. This curve is generally used in calculations of steam engines as the relation of pressures and volumes of saturated steam is approximated by the curve.

Isothermal Lines.—1. In physics, lines of equal temperature, as opposed to adiabatic curves. Isothermal lines are those produced on diagrams of work under varying pressure with constant temperature.

2. Lines drawn upon a map passing through points upon the earth's surface which have the same mean temperature.

Isothermal Surfaces.—Surfaces having the same temperature.

Isotropic.—A term applied to bodies which have equal properties in all directions.

Isotropic Conductor.—A conductor having equal properties of electrical conduction in every direction through its mass.

Isotropic Dielectric.—A dielectric having equal properties of induction in every direction through its mass.

Isotropic Medium.—Any medium having equal properties in all directions.

Isthmus Method of Magnetization.—A method by which magnetization may be strongly concentrated by placing a narrow neck of iron between the poles of an electromagnet.

Isynchronous Vibrations.—Vibrations which occur in harmony or in equal times.

J.—Abbreviation for *joule*, unit of electrical energy. *Watt-hour.*

Jablochkoff Candle.—An early form of arc lamp consisting of two parallel carbons separated by a thin strip of insulating material, the electric arc being formed across the tips of the two carbons, and maintained by an alternating current in order that both carbons may consume equally.

Jablochkoff Igniter.—A little carbon strip placed across the tips of the parallel carbons of a Jablochkoff candle in order to start the arc between them.

Jablochkoff, Paul.—Born 1847, died 1894. A Russian electrician, noted for the invention (1878) of an early type of arc lamp known as the *Jablochkoff candle.*

Jack.—In telephony, a *spring jack*; a form of metallic spring contact set in the switchboard and forming the termination of a subscriber's line, connections with which are made by three wire cords terminating in *plugs* which are inserted through a hole in the board leading into the jack.

Jacket.—1. A covering for a steam cylinder, pipe, or the like, to prevent the escape of heat.

2. An annular space surrounding an engine cylinder into which live steam is admitted to prevent initial condensation of the steam within the cylinder.

Jacketed Magnet.—A term sometimes applied to a short cylindrical electromagnet having an outer tube united to the iron core at the bottom; *an iron-clad magnet.*

Jack Hole.—A hole in a telephone switchboard through which a plug is inserted into a spring jack.

Jack Panel.—A panel in a telephone switchboard supplied with spring jacks.

Jack Screw.—A device for raising heavy weights, in which the power of the screw is applied.

Jack Switch.—A switch controlled by a spring jack.

Jacobi, Moritz Hermann von.—Born 1801, died 1874. A German physicist. He invented the first electromotor (1834), and a process of electrotyping (1839), besides carrying on important researches in physics. In 1835 he published a remarkable essay on the application of electromagnetism to the operation of machines, and another on galvanoplastics in 1840.

Jacobi's Law.—A law applied to electric motors, *viz.:* that the maximum work is done by an electric motor when the counter-electromotive force equals one-half of the impressed electromotive force.

Jacobi's Unit of Current.—A unit of electric current equal to .0961 of an ampere; a current which will liberate a cubic centimeter of oxygen and hydrogen per second in a water voltameter, the gases being taken at a temperature of 0° C., and a barometric pressure of 760 millimeters.

Jacobi's Unit of Resistance.—A unit of resistance equal to .6296 of a legal ohm; it is the resistance offered by a certain copper wire 25 ft. in length and weighing 345 grains.

Jag Bolt.—In machinery, a tail bolt whose shank or tail is roughed up by jagging.

Jamming.—In steam engineering, the sticking of cocks and safety valves in their seatings, due to a wedging action induced by various circumstances. Safety valves jam by reason of corrosion or distortion, cocks through too slight an angle being given to their plugs, and also from corrosion.

Jam Nut.—A nut, placed in contact with the main nut on the same bolt, to keep the main nut from turning.

Jandus Lamp.—A form of arc lamp in which the arc itself is enclosed in a small and almost air tight glass cylinder. The outer globe is arranged with asbestos washers preventing the ingress of air. Under such conditions, the consumption of carbon is considerably reduced, and, owing somewhat to the pressure of the inert gases inside the small glass cylinder, the voltage can be increased and the arc correspondingly lengthened.

The only moving parts when the lamp is burning are the electromagnet core, pole piece, and the attachment for operating the carbon.

Japan.—A variety of enamel sometimes used for the insulation of electrical machines, as when the smooth core of an armature is japanned to increase the insulation of the conductors from the iron body. Japan is a varnish which is dried in a hot stove after application of each coat, giving a brilliant and durable surface.

Jar.—A vessel, as of earthenware or glass, with a large body and broad mouth.

Jar Battery.—A battery of Leyden jars for accumulating a large charge of electricity for experimental purposes. The jars are grouped with all their inner coatings connected together and their outer coatings joined. A battery of this kind is capable of giving a powerful shock.

Jar, Electric.—The Leyden jar, an early form of electric condenser. It consists of a wide mouthed glass cylindrical vessel coated inside and out, up to a certain distance from the top, with tin foil. The coatings form the two plates of the condenser which can be charged to a high potential difference by an electrostatic machine. By connecting the inner surface of the foil, which is connected to a brass knob at the top, with the outer coating, a powerful spark discharge may be obtained. The capacity of a Leyden jar is equal to the quantity of electricity divided by the voltage which such quantity produces.

Jar of Storage Battery.—An almost rectangular jar open at the top for containing the electrolyte and lead plates of a storage cell.

Jaw.—1. A grasping tool having jaws; as, a monkey wrench.

2. One of a pair of members between which a piece of material is held, crushed or cut; as, the jaws of a vise.

Jaws of Switch.—The metal contact plates into which fit the blades of a knife switch.

Jenkin, Henry Charles Fleeming.—Born 1833, died 1885. A Scottish engineer and electrician, distinguished for his experiments with electric cables (1858-73), and for his work on electrical standards (1861).

Jet Condenser.—A chamber or vessel within which the exhaust steam from an engine meets a spray or jet of water and is condensed. The heated cooling water, condensed steam, and liberated air are removed from the condenser by the air pump, which delivers the water into the hot well, whence the feed water supply is taken by the pumps, the surplus escaping through the overflow.

The jet condenser is commonly used where a large quantity of fresh water is available. Under ordinary conditions, the temperature of the hot well varies from 110° to 130° F. Usually the amount of injection water required is from twenty-five to thirty times the feed water. The exact amount is:

$$Q = \frac{WH}{R}$$

in which, Q = pounds of injection water per pound of steam condensed; W = weight of steam condensed; H = heat units given up by one pound of steam in condensing; R = rise in temperature of the injection water.

Jet Photometer.—An instrument for measuring the intensity of a gas light by taking into consideration the height of a burning jet under uniform pressure and temperature conditions.

Jewel.—In electric measuring instruments, sapphire or agate points employed as pivots in preference to friction wheels, knife edges, etc. Agate is harder than sapphire, but more liable to crack, so that for heavy movements and those subject to vibration and rough usage sapphire is better.

Jewelry, Electric.—Miniature incandescent lamps mounted as scarf pins or other ornaments.

Jib Crane.—One that lifts weights at the extremity of an inclined arm or jib; this differs from a derrick, in that the load cannot be lifted by the topping lifts or peak blocks, as the jib is supported by rigid stays.

Jigger.—A peculiar type of transformer of high frequency currents employed in the Marconi system of wireless telegraphy.

Jockey Gear.—A gearing connected with a cable laying apparatus, consisting of so called jockey wheels which ride over the cable as it passes over the drum and preserve a uniform tension so as to avoid slipping.

Jockey Wheel.—A heavy wheel which rides over the cable upon the drum of a cable laying apparatus, so as to maintain the tension and avoid slip.

Joining Up.—The act or process of making an electrical connection.

Joining Up a Wire.—Bringing a wire into electrical connection with a circuit.

Joint.—1. The point at which a junction is made.

2. The junction by which any two parts are united.

A good electrical joint should have conductivity, mechanical strength, durability, and facility for insulation. In making a joint it may be brazed, soldered, welded, or as usually made, the two ends of the conductors are brought into close metallic contact and secured in position by twisting the ends. This is known as a *dry joint.*

Joint Admittance.—The combination of several parallel-connected admittances.

Joint Conductance.—The combination of several parallel-connected conductances.

Joint Cooling Tray.—A tray containing ice water, or a special cooling mixture, employed to hasten the cooling of a cable core joint.

Jointless Conductor.—A conductor formed of a single length of wire, and therefore free from joints.

Joint Magnetomotive Force.—A combination of several magnetomotive forces acting together.

Joint Pin.—A pin on which a double eye or forked joint is hinged, the pin fitting tightly in one member and hinged in the other.

Joint Reluctance.—The combination of several parallel-connected reluctances.

Joint Resistance.—The combination of several parallel-connected resistances.

Joint Trough.—A trough containing ice water or a special cooling mixture employed to hasten the cooling of a cable core joint.

Joule.—The practical unit of electrical *energy*, equal to 10^7 absolute units or ergs; the amount of work done when one coulomb of electricity moves under a pressure of one volt; *the volt coulomb*. It derives its name from J. P. Joule, the English scientist. One joule is equal to .73732 foot pounds or .24 calorie. One joule per second equals one watt; 4.2 joules equal one small calorie.

Joule Effect.—The heat produced by the resistance offered by a conductor to the flow of an electric current.

Joule, James Prescott.—Born 1818, died 1889. An English physicist. At the age of nineteen, he invented an electromagnetic engine. He was the first to ascertain the mechanical equivalent of heat, working for forty years in its determination. In 1847 he stated the doctrine of the conservation of energy. He made many important researches in electricity and thermodynamics, discovering the law known as Joule's law for determining the relation between the heat and the current pressure and time in an electric circuit. His name has been given to the unit of electric work, the joule.

Joule Meter.—An instrument for measuring electrical energy in terms of the joule.

Joule Per Second.—A unit of electrical activity involving the work of one joule during one second of time.

Joule's Electromagnet.—An electromagnet having a hollow cylindrical core with a segment cut off along its length.

Joule's Equivalent.—The mechanical equivalent of heat, or the value of the heat unit in terms of work. The mechanical equivalent of one British heat unit, as found by Joule the English physicist, is 772 foot pounds for 1° F. It is the power expended to raise 1 lb. of water 1° F. Experiments by Rowland and others give higher figures. The accepted value is taken at 778 foot pounds.

Joule's Law.—The law first stated by Joule, that the quantity of heat developed in a conductor by the passage of an electric current is proportional to the resistance of the conductor, to the square of the strength of the current, and to the duration of the flow.

Expressed as a formula:

$$H = I^2Rt,$$

$$\begin{aligned} \text{or, heat} &= \text{current}^2 \times \text{resistance} \times \text{time.} \\ &= \text{pressure} \times \text{current} \times \text{time.} \\ &= \text{pressure}^2 \times \text{time} \div \text{resistance.} \\ &= I^2Rt \times .239 \text{ gram calories.} \\ &= I^2Rt \times .000957 \text{ British Thermal Units.} \end{aligned}$$

Journal Friction.—The friction of a shaft in its bearings. From experiments, it appears that the friction of a perfectly lubricated journal follows the laws of liquid friction much more closely than those of solid friction. According to Thurston,

gun bronze, babbitt, and other soft white alloys have substantially the same friction; in other words, the friction is determined by the nature of the unguent and not by that of the rubbing surfaces, when the latter are in good condition. The soft metals above referred to on account of deficient conductivity, run at higher temperatures than the bronze.

Jumper.—1. A short length of wire employed to make a connection around a break in a circuit; or attached around an electrical instrument as a short circuit whereby it may be readily removed.

2. A bridle wire for connecting the terminals on the line side of a telephone distributing board and the corresponding wires leading from the switchboard.

Jumping Point.—In testing the range of arc light carbons, a point during the lengthening of the distance between the carbons at which the arc makes small jumps or sputters out of the crater in the upper carbon.

Jump Spark.—1. In general, a spark resulting from a sudden discharge taking place between two charged bodies across an intervening non-conductor.

2. In electric ignition for internal combustion engines, a system in which the primary current is converted by an induction coil into a secondary current of sufficiently high tension to cause a spark to jump an air gap between two points carried by a spark plug screwed into an opening in the cylinder of the engine.

Jump-Spark Burner.—A variety of gas burner in which the gas is lighted by a jump spark across two electrified points.

Junction Board.—A telephone switchboard for the terminals of junction lines.

Junction Box.—A box, or casing, provided in an underground distribution system in which the feeders and mains are connected and other connections are made: *a fishing box.*

Junction Calls.—Calls received at a telephone exchange over a junction line.

Junction Circuit.—A telephone circuit joining a trunk line circuit with a subscriber.

Junction Line.—A telephone line between two exchanges, as distinguished from a subscriber's line; *a junction.*

Junction Line Plug.—A contact plug in a telephone junction board.

Junction Operator.—An operator at a telephone junction board in a central exchange.

Junction Surface of Primary Cell.—In a primary cell, the surface of the electrodes in actual contact with the electrolyte.

Junction Wire.—The junction line between two telephone exchanges.

Junction Working.—Telephone working between exchanges.

Junk.—Old rope; old planking; scrap iron; odds and ends.

Just Non-oscillatory Discharge.—An electric discharge which just fails to be an oscillatory discharge.

Jute.—The coarse strong fiber of an East Indian plant largely used for gunny sacks, cordage, etc. In electric practice, jute is employed as an insulating material, especially when saturated with *an insulating compound.*

K.—1. The symbol of electrostatic capacity.

2. The symbol for specific inductive capacity.

κ.—The Greek small letter *kappa*, the symbol of *magnetic susceptibility*.

Kaolin.—A white clay resulting from the decomposition of feldspar, used for making the finest porcelain, hence the name, *china clay*. Experiments have been made with kaolin for insulating purposes.

Kapp Line.—A unit line of magnetic force proposed by Kapp. It is equal to 6000 C. G. S. lines of force, with the square inch as the unit area.

Karsten's Figures.—A name sometimes given to *breath figures* which are produced by electrifying a coin or other piece of metal resting upon a sheet of dry glass and then breathing upon the place where the coin lay. In this way a faint image of the coin is reproduced upon the glass.

Katalysis.—An unusual spelling of catalysis.

Kathion.—An occasional form of spelling cation.

Kathode.—An occasional form of spelling cathode.

k. c. c.—Abbreviation for cathodic closure contraction.

k. d. c.—Abbreviation for cathodic duration contraction.

Keeper.—1. The armature of a magnet; the bar of soft iron placed across the poles of a horse shoe magnet to prevent loss of magnetism.

2. A name sometimes given to one of the *inductors*, or heavy masses of soft iron carried upon the rotor of an inductor alternator.

Kelvin Balance.—An accurate standard instrument invented by Lord Kelvin for measuring electric currents by their direct magnetic action.

Kelvin, William Thomson (1st Baron).—Born 1824, died 1907. A noted British physicist, electrician and inventor. After completing his education at Glasgow and Cambridge, he became professor of natural philosophy, first at Cambridge, then at Glasgow University, serving in the latter capacity for over fifty years. During the period of laying the first Atlantic cables, 1857-1866, already enjoying the reputation of being England's greatest electrician, he was called upon to lend his knowledge to assist in the project. At this time he invented the mirror galvanometer and the siphon recorder. After this he was engaged in several cable laying undertakings for a period of ten years. Among his notable inventions, in addition to the reflecting galvanometer and siphon recorder, may be mentioned the compensating mariners' compass, a tidal gauge, a tide predicter and the deep sea sounder, but his greatest work was done in connection with electric measurement devising measuring instruments of great precision for the various electric quantities. He received high honors in England, America and elsewhere, and as the greatest final honor his country could bestow, he was buried in Westminster Abbey.

Kerite.—A variety of artificial vulcanite prepared for insulating purposes.

Kerite Tape.—Tape insulated by a coating of kerite.

Kerosene.—A mineral hydrocarbon oil, distilled from petroleum or coal oil. It is the second series of fractional distillates, first coming the lightest or gasolenes; then the illuminating oils or kerosene; then "solar oil" for gas enrichment, "middlings" used as fuel, and the final residue, whose uses vary with the nature and locality of the petroleum, sometimes being used as fuel, sometimes having lubricating oils of different densities distilled from it, until nothing is left but a solid residue or coke.

Kerr Effect.—The effect produced in dielectrics when subjected to electro-static stresses, so that they become double refracting in their relation to a beam of polarized light. Dr. Kerr showed, in 1877, that a ray of polarized light is also rotated when reflected at the surface of a magnet. If the light be reflected at a point on the side of the magnet, when the plane of polarization is parallel to the plane of incidence, the rotation is in the same direction as that of the magnetizing current.

Key.—In telegraphy, a device for making or breaking the contacts which control the passage of the current; a steel lever, swung

on a pivot, having a rubber handle, which the operator grasps lightly with the thumb and forefingers. On pressing the lever downward, a platina point projecting under the lever is brought into contact with another platina point set into an insulation of rubber in the base of the key, so that there can be no electrical connection between them unless the key is pressed down or *closed*.

An extra lever at the side of the key is called the "circuit-closer," and is used as a means of keeping the circuit closed when the hand of the operator is not on the key. When the circuit-closer is pushed into its closed position, it makes contact with a brass lip, which latter is fastened to the rubber along with the lower platina point. This, then, has the same effect as though the key was pressed downward and contact made at the points.

Keyboard.—A board upon which electric switches are mounted.

Keyboard Transmitter.—A variety of telegraph transmitter used with the printing or dial telegraph system.

Key Lamp Socket.—A lamp socket having a switch for opening and closing the circuit of the lamp.

Keyless Fire Alarm Box.—A type of fire alarm box, which, instead of opening with a key, has a glass front which must be broken before the alarm can be set.

Keyless Lamp Socket.—A lamp socket having no switch.

Keyless Wall Socket.—A lamp socket fitted to a wall having terminals to which the flexible wires leading to the lamp are connected by a plug block.

kg.—Abbreviation for kilogram.

kg. m.—Abbreviation for kilogram meter.

Kick.—1. In general, a recoil.

2. Any impulsive movement imparted in telegraphy to delicate instrument parts by a discharge from the line.

Kicking Coil.—A name sometimes given to a choke coil consisting of ten or more turns of base copper introduced into a feeder wire at the point when it leaves the station, to protect machines from surge currents and lightning discharges.

Kick of Coil.—A discharge taking place from an electromagnet coil.

Kick of Relay.—An impulsive movement imparted to the tongue of a telegraphic relay by an electric discharge from the line.

Kilerg.—The same as kilo-erg.

Killing Wire.—1. A method of straightening wire by applying tension to it.

2. The loss of elasticity suffered by the contact springs of switches when heated to excess by the electric current.

Kilo.—A prefix often used with a physical unit to designate a quantity one thousand times as great.

Kilo-ampere.—A unit of current, equal to 1000 amperes.

Kilo-ampere Balance.—An ampere balance which measures electric current in terms of kilo-amperes.

Kilo-dyne.—A unit of force, equal to one thousand dynes.

Kilo-erg.—A unit of work, equal to one thousand ergs.

Kilo-gauss.—A unit of magnetic flux density, equal to one thousand gausses.

Kilogram.—A unit of mass in the metric system corresponding to a standard mass of platinum kept in Paris, equal to one thousand grams or 2.2046 lbs.: abbreviated kg.

Kilogrammeter.—A unit of work; the work done by a force equal to the weight of one kilogram acting through a distance of one meter, 7.233 foot pounds.

Kilo-henry.—A unit of self-induction, equal to one thousand henrys.

Kilo-joule.—A unit of work, equal to one thousand joules.

Kilo-line.—A unit equal to one thousand lines of force.

Kilometer.—A unit of length in the metric system equal to one thousand meters, 3280.899 ft., or 0.62138 statute miles.

Kilometric Capacity of Cable.—The capacity of a cable measured in microfarads per kilometer.

Kilometric Insulation of Cable.—The insulation of a cable measured in megohms per kilometer.

Kilo-volt.—A unit of electromotive force, equal to one thousand volts.

Kilo-volt Ampere.—Apparent power in alternating current circuits is expressed in kilovolt amperes when the real power is expressed in kilowatts.

Kilowatt.—A unit of electric power, equal to one thousand watts, especially applied to the output of dynamos. Electric power is usually expressed in kilowatts. As the watt is equal to $\frac{1}{746}$ horse power, the kilowatt equals $\frac{1000}{746}$ or 1.34 h. p.

The kilowatt is sometimes, erroneously, called the unit. Thus, a fifty kilowatt generator is sometimes spoken of as a fifty unit machine.

Kilowatt Hour.—The work performed by one kilowatt of electric power during an hour's time.

Kilowatt Hour Meter.—A type of recording wattmeter measuring in terms of kilowatt hours.

Kilo-weber.—A unit of magnetic flux equal to one thousand webers.

Kine.—A term proposed for the C. G. S. unit of velocity equal to one centimeter per second.

Kinematics.—1. That branch of mechanics which treats of motion without reference to mass or to the causes of motion, as distinguished from *dynamics*.

2. The theory of the motions of parts of machines whereby they are constrained to fulfill their various functions, one variety of motion being employed to produce another.

Kinetic Energy.—The energy possessed by a moving body *in virtue* of its motion, as distinguished from potential energy, or that possessed by a stationary body tending to motion. It represents the work necessary to bring the body from its actual velocity to a state of rest. The measure of actual energy is the product of the weight of the body, multiplied by the height from which it must fall to acquire its actual velocity.

Kinetics.—That branch of dynamics which treats of forces that cause or change motion in bodies, as opposed to *statics*.

Kinetic Theory of Gases.—That theory of the properties of gases based upon the assumption that a gas consists of separate molecules, each possessing a finite mass and velocity, and obeying the ordinary laws of motion.

Kinetic Theory of Matter.—The theory that the molecules composing matter are in a perpetual state of rapid motion, constantly colliding with one another.

King Leg.—The principal or vertical leg of a *tripod* supporting a derrick, etc.; the other legs are known as *queen legs*.

King Post Truss.—A truss or roof principal constructed with a king post.

Kinnersley's Thermometer.—An electric air thermometer consisting of a glass vessel enclosing air, and communicating with a tube partly filled with water or other liquid. Two metal rods are led into this tube and a filament of gilt paper or thin wire is suspended between the two rods. When an electric discharge passes between the rods, the enclosed air is heated and expands which causes a movement in the indicating column of liquid. Observations with the instrument show: (1) That the heating effect of a charge in a wire of given length is inversely proportional to the square of the wire's cross section area: (2) that the total heat evolved is jointly proportional to the strength of the charge and to the fall of pressure.

Kirchoff, Gustav Rebert.—Born 1824, died 1887. A German physicist, discoverer, jointly with Bunsen, of the method of spectrum analysis (1859); author of the so called Kirchoff's laws.

Kirchoff's Laws.—Two important laws given by Kirchoff, viz.: (1) In a network of conductors the sum of all the currents that flow towards a junction is equal to the sum of the currents which flow away from that point. (2) In a complete electric circuit the sum of the electromotive forces round the circuit is equal to the sum of the resistances of its separate parts multiplied each by the strength of the current flowing through it.

Kish.—A shop term for the black scales of graphite which separate and float on the surface of a slowly cooling mass of molten iron. The whole of the *scum* is also called kish.

Kit.—A box containing implements; an outfit of tools, accessories or personal possessions for any particular calling; such as a plumber's kit of tools, or a sailor's kit of clothing; small implements and personal necessities.

Kneading Tools.—Tools for pressing into shape hot gutta percha when covering an insulated joint.

Knife Break Switch.—A switch consisting of a movable blade of copper or brass which makes electric contact between two contact springs.

Knife Edge Suspension.—A suspension resting upon a sharp edge of steel or agate, employed for accurate balancing.

Knife Switch.—A switch having a movable blade of copper or brass which makes a contact between two parallel contact springs. Jack-knife or knife blade switches are made single, double or triple pole.

Knot.—A nautical mile, equal to 6080.44 feet, or 1.15 statute miles.

Knot Pound.—A conductivity standard, applied to the copper of submarine cables.

Knurled.—1. Having knurls; that is, full of or covered with knots and protuberances.

2. Milled; having the edges cut into a succession of ridges to afford grip for the fingers; as, the head of a screw or the edge of a coin.

Kohlrausch, Friedrich Wilhelm Georg.—Born 1840. A German physicist, distinguished for his researches in various departments of physics, especially in electrolysis and the absolute measurement of resistance; author of the law of electrolysis which bears his name.

Kohlrausch's Law.—A law applied to the atoms in a solution undergoing electrolysis, viz.: that the rate of motion of each atom for a given liquid is independent of the element with which it may have been in combination.

KR.—Abbreviation for the capacity of a conductor, K, multiplied by its ohmic resistance R.

Krizik's Cores.—Iron bars for magnetizing cores so shaped that the attraction or pull is nearly equal in all positions of the solenoid.

KR Law.—A law relating to submarine cables, that the limiting speed of signaling varies inversely as the product of the capacity K by the resistance R.

Krüss' Optical Scale.—A scale devised for obtaining the dimensions of a flame.

Kryptol.—A mixture of graphite, carborundum, silicate and clay in granular form, employed in electric furnaces.

K. W.—Abbreviation for kilowatt.

Kyanize.—To preserve wood, such as telegraph poles, from decay, by a process of impregnation with a solution of corrosive sublimate, or chloride of mercury. The proportions are one pound of sublimate to ten gallons of water for maximum strength, or one pound to fifteen gallons as a minimum. About twenty-four hours per inch of thickness are required for saturation.

L.—The symbol for coefficient of inductance or *self-induction.*

Labile Galvanization.—In electro-therapeutics, the process of applying the current to any part of the human body, in which one electrode is fixed and the other is moved with a slipping motion over the parts treated

Laboratory.—A place where operations and experiments are performed; a place where anything is prepared for use.

Lag.—The retardation of an alternating current behind the impressed E. M. F. which produces it.

Lagging.—Non-conducting material placed around boilers, pipes, engine cylinders, etc.

Lagging a Meter.—Adjusting a wattmeter so that it shall read correctly on inductive and non-inductive loads.

Lag of Electromotive Force.—The retardation of electromotive force behind the current.

Lag of Magnetization.—A retardation of magnetic effects behind their causes, due to hysteresis in the magnetized substance.

Lag of Motor Brushes.—Shifting the brushes upon the commutator in a direction opposite to the rotation in order to avoid sparking.

Lag of Resultant Flux.—In an induction motor, the retardation of the induced magnetic flux behind the impressed magnetic flux.

Lalande Cell.—Better known as the Edison-Lalande or Edison cell. The positive plate consists of compressed oxide of copper with its surface reduced to oxide of copper for better conductivity; the negative plate is of pure zinc amalgamated; the electrolyte is a solution of caustic soda. It is suitable for either open or closed circuit work.

Lambert's Discharge Key.—A type of double contact key highly insulated for testing purposes.

Lamellar.—Arranged in thin plates, scales or layers.

Lamellar Distribution of Magnetism.—A distribution of magnetism such that the substance in which it exists can be divided into thin shells or layers, in which the magnetic particles are so arranged that one face of each layer contains all the north poles and the other face all the south poles, thereby producing a strong field.

Lamellar Magnet.—A magnet possessing a lamellar distribution of magnetism.

Lamina.—A thin layer of metal or mineral, as of mica, tissue, etc. *Laminae* is the plural of *lamina.*

Laminate.—To beat, roll or press into thin sheets, as a metal.

Laminated Brush.—A commutator brush composed of thin leaves or layers of metal, usually copper.

Laminated Core.—An armature core built up of layers of insulated iron plates in order to prevent the formation of Foucault currents in the metal.

Laminated Magnet.—A magnet having a laminated core.

Laminated Springs.—These are constructed of long, narrow, flat plates of spring steel, bent to a camber or curve, fastened in the middle by a buckle, with a suitable attachment to the load, and supported at the ends by links or hangers.

Lamination.—1. Building up a mass of metal of flat thin plates; as, the cores of electrical transformers.

2. In geology, the natural arrangement of rocks so that they split into thin sheets.

Lamination of Armature Core.—The building up of a dynamo or motor armature with a number of thin discs cut or stamped

out to the required shape and bolted together, for the purpose of reducing the tendency to eddy currents.

Lamination of Conductor.—The formation of a stranded conductor by laying up parallel wires in the place of a solid core, thereby reducing the tendency to eddy and skin currents.

Lamp Adapter.—A contrivance to adapt an incandescent lamp to any bracket or chandelier; or to adapt lamp bases to sockets of different make.

Lamp Annunciator.—In telephone switchboards, miniature incandescent lamps employed instead of mechanical drops for attracting the attention of the operator. They are usually one-third candle power lamps mounted in opaque tubes with small opalescent glass jewels.

Lamp Base.—The brass base which is cemented by plaster to the bulb of an incandescent lamp, and which contains the contacts for bringing the filament into connection with the electric circuit.

Lamp Bracket.—A bracket designed to support an electric lamp.

Lamp Bulb.—The glass vacuum chamber containing the filament of an incandescent lamp; the lamp chamber.

Lamp Cap.—A term sometimes applied to the base of an incandescent lamp.

Lamp Chamber.—A term sometimes applied to the glass bulb of an incandescent lamp.

Lamp Circuit.—The circuit supplying the current to a system of electric lamps. Circuits may be divided into two kinds, viz.: series circuits, and parallel or shunt circuits. In the series circuit, the wires, lamps, etc., are arranged end to end. The current passes in succession through each of the lamps or other appliances composing the circuit. In the parallel or shunt circuit, two main wires or leads are connected to the points of higher and lower potential, and the lamps, wires, etc., are connected across the two mains, or arranged side by side. The current divides itself amongst these branches in inverse proportion to their resistance. If the resistances of all the branches are equal, the total resistance of the circuit will be equal to the resistance of one branch divided by the number of branches. The total resistance of the series circuit is equal to the sum of the resistances of each of its separate parts.

Lamp Clamp.—A clutch designed to grip the carbon holder of an arc lamp.

Lamp Contacts.—Metallic parts placed in the base of an incandescent lamp, by which the filament is brought into connection with the circuit.

Lamp Cord.—The flexible cord composed of two insulated conductors, used in connection with pendant incandescent lamps.

Lamp Cut Out.—1. An automatic device for cutting an arc lamp out of a circuit when its carbons become consumed.

2. An automatic cut out, used with series connected incandescent lamps, which acts promptly when a circuit through a lamp is broken, and short circuits it.

Lamp Dimmer.—A resistance box or reactive coil connected in series with the lamp circuit of a theater or public hall, for reducing the light of the lamps when desired. Resistance boxes may be used with either direct or alternating currents. Reactive coils can be used with alternating currents only.

Lamp Efficiency.—The efficiency of an electric lamp refers to the power consumed per candle power. In other words, the efficiency of a lamp is stated in terms of the mean spherical candle power per watt at the lamp terminals.

Lamp, Electric.—A lamp which depends for its source of light upon the effects of an electric current. Electric lamps may be grouped into three classes: (a) *incandescent* lamps in which the source of light is the incandescence of a refractory substance upon the passage of a current; (b) *arc* lamps in which a luminous arc is maintained by an electric current between suitable electrodes; and (c) *vapor* lamps in which the vapor in an exhausted glass tube becomes an incandescent stream of high conductivity.

Lamp Feet.—In a system of electric lighting, a sum obtained by multiplying the number of lamps by the distance to each lamp in feet.

Lamp Filament.—The conducting thread which becomes incandescent upon the passage of an electric current employed as the source of light in an incandescent lamp. A great many materials have been employed for this purpose. Early experiments began with carbonised bamboo fiber, carbonized paper and silk or cotton thread Cellulose threads prepared by the *squirting* process and

carbonised and *flashed* have for many years been the prevailing filament, but rare metals such as tungsten, and tantalum show higher degrees of efficiency.

Lamp Frame.—The structural frame which supports the essential parts of an arc lamp.

Lamp Hanger.—A board provided with the parts required for the suspension of an arc lamp; a *hanger board.*

Lamp Hour.—A unit of electric light service, equal to the currents required for one lamp during one hour.

Lamp Indicator.—1. A device in a central station by which the condition of the electric current in the mains may be observed.

2. A miniature incandescent lamp used in a telephone switchboard as a signal to the operator that a subscriber is calling.

3. A pilot lamp.

Lamp Panel.—A group or "bank" of incandescent lamps mounted upon a single base and serving as a voltage indicator, or to show the occurrence of faults in the line.

Lamp Pendant.—The lamp cord used in connection with a pendant incandescent lamp.

Lamp Pillar.—A pillar upon which electric lamps are supported.

Lamp Protector.—A wire guard or other device for protecting an electric lamp.

Lamp Receptacle.—A term sometimes applied to a lamp socket.

Lamp Rod.—The metallic rod by which the positive carbon of the usual type of an arc lamp is supported.

Lamp Signal Switchboard.—A telephone switchboard employing miniature incandescent lamps as annunciators, instead of mechanical drops.

Lamp Socket.—The socket provided with contacts, into which the base of an incandescent lamp is designed to fit; *the lamp receptacle.*

Lamp Socket Rheostat.—A resistance placed within the socket of an incandescent lamp, by which the intensity of the light can be varied.

Lamp Socket Switch.—A key or switch in an incandescent lamp socket by which the lamp may be lighted or extinguished

Lamp Switches.—Switches in a lamp circuit for controlling one or more groups of lamps.

Lamp Tests.—M. André Larnaude, as the result of a series of tests, estimates that the life of an incandescent lamp increases much more rapidly than its efficiency decreases, also that lamps run so as to absorb:

2.5	watts	per	candle,	last	for	150	hours
3.0	"	"	"	"	"	350	"
3.5	"	"	"	"	"	700	"
4.0	"	"	"	"	"	1000	"

Very different figures are given by Siemens and Halske of Berlin, whose experiments tend to show the following to be the duration of 16 candle power lamps:

1.5	watts	per	candle,	last	for	45	hours
2.0	"	"	"	"	"	200	"
2.5	"	"	"	"	"	450	"
3.0	"	"	"	"	"	1000	"
3.5	"	"	"	"	"	1000	"

After a lamp has burned 500 or 600 hours it is more economical to replace it with a new one if the price of current is that usually charged by central stations. A lamp will give only 60 to 70 per cent of its rated power during the later half of its life.

Land Line.—1. A telegraph line for overland service.

2. The portion of a submarine cable system extending upon land.

Lantern Lamp.—An incandescent lamp having a lantern chamber and guard outside of the bulb.

Lanthanum.—A rare metal belonging to the same group as aluminum.

Lanyard.—A piece of cord or line for seizing or fastening anything.

Lap Joint.—1. A joint for wires in which the two ends are laid side by side, bound together and soldered. The Britannia joint is a type of lap joint.

2. In belting, a joint made by overlapping the ends and securing them together.

Lap of the Slide Valve.—1. In a steam engine, the lap of the slide valve on the steam side is the distance the outer or steam edge of the valve extends beyond, or laps over the outer or steam edge of the port when the valve is in its central position. It is given for the purpose of causing the engine to work expansively, by cutting off the admission of steam before the end of the stroke, and is called *outside lap.*

2. Also the lap which controls the exhaust and causes the passage to the condenser to be closed before the end of the stroke; the piston is then said to be *cushioned* by the elasticity of the confined vapor upon which it descends. This is called *inside lap*, and is the distance the inner or exhaust edge of the valve extends beyond or laps over the exhaust edge of the port when the valve is in its central position. Sometimes the inside lap is made zero or even *negative*.

Lap Winding.—A method of winding armatures of alternating current dynamos, in which the wires lap backwards towards the point at which the winding began; loop winding.

Largo Calorie.—The great calorie. A heat unit equal to the amount of heat required to raise the temperature of one kilogram of water one degree Centigrade. It is 1,000 times as great as the calorie.

Lasher.—A piece of rope for binding or making one thing fast to another.

Latent.—Hidden; not apparent, yet existing concealed.

Latent Heat of Steam.—Insensible heat; in heating water a certain proportion of the heat which has been absorbed, is not shown by the thermometer or by touch. There are two sorts or conditions of heat in the process of steam production operating upon water: (1) sensible heat; (2) latent or insensible heat; hence the constituent, or total heat of steam consists of its latent heat in addition to its sensible heat. In generating water into steam there is absorbed about five and one half times as much heat as is required under atmospheric pressure, to raise the temperature of the water from freezing point, 32° Fah., to boiling point, 212° Fah., an amount of heat which if the water were a fixed solid would, it is said, render it *red hot* by daylight. Tested by a thermometer the steam will show only 212°, but by experiment 965.7 heat units have been added, which is stored up in some unaccountable way and is called the *latent* heat of steam.

In some steam tables, such as Buel's, the latent heat of steam is divided into two elements, as follows: (1) The heat required to evaporate the water at the temperature of the steam, called *internal latent heat;* (2) the external work done by the steam in making room for itself against the pressure of the atmosphere (or surrounding steam if enclosed in a boiler), called the *latent heat of volume.*

Lateral.—1. Proceeding from or attached to the side; as, lateral force.

2. In a system of conduits, a branch conduit to provide for the connection of service wires: an offset.

Lateral Bracket.—A type of high insulation bracket designed to be attached to the corner of a building for the support of an overhead wire.

Lateral Discharge.—An impulsive discharge, as from a Leyden jar, taking place through an alternative path which offers less resistance than the direct path.

Lateral Induction.—The induction which accompanies a lateral discharge taking place between circuits in close proximity to each other.

Lateral Magnetic Leakage.—Leakage of magnetism from points upon the surface of a magnet other than its poles.

Lateral Motion.—That in a sidewise direction; a swaying movement.

Lateral Strain.—In mechanics, a strain which bears against *the sides* of a structure, being essentially a transverse strain.

Latitude.—1. The width or breadth of anything; sidewise extent.

2. Extent within limits; scope or comprehensiveness.

3. The angular distance of any place measured north or south of the equator along the meridian of that place.

Lattice Pole.—A type of iron pole with lattice work construction for bearing special strain in carrying overhead wires or cables.

Lattice Work.—The lattice work construction sometimes employed for line wire poles designed to bear special strain in carrying overhead wires or conductors.

Launch, Electric.—An open boat propelled by an electric motor operated by a storage battery placed under the floor or seats.

Lava.—A name often given to a form of talc, sometimes used as an insulating material in spark plugs for gasoline engines.

Law.—In physics, a certain and fixed rule of cause, being, action, or change, in physical phenomena.

Law of Boyle.—A law of the compressibility of gases announced by Boyle in 1662, and later by Mariotte. It may be stated thus: The volume of a gas is inversely proportional to the pressure to which it is subjected at a constant temperature. Usually known as *Boyle's law*, and sometimes as *Mariotte's law*.

Law of Charles.—*The volume of a perfect gas at a constant pressure is proportional to its absolute temperature. Expressed as a formula:*

$$v_1 = v_0 \left(\frac{t_1 + 459.2}{491.2}\right)$$

in which, v_0 = the volume of a gas at 32° F., and v_1 the volume at any other temperature t_1.

Law of Coulomb.—The same as the law of inverse squares.

Law of Illumination.—The intensity of light at any point of an illuminated surface varies inversely as the square of the distance from that point to the source of light.

Law of Inverse Squares.—The force exerted between two magnetic poles is proportional to the product of their strengths, and inversely proportional to the square of the distance between them. Also known as *Coulomb's law.*

Law of Joule.—A law relating to the heat developed by an electric current discovered by Joule, viz.: the number of units of heat developed in a conductor is proportional (a) to its resistance; (b) to the square of the strength of the current; and (c) to the time that the current continues to flow. Usually called *Joule's law.*

Law of Lenz.—In electromagnetic induction, the direction of the induced current is such as to oppose the motion producing it; *Lenz's law.*

Law of Ohm.—A law of the inter-relation of current, electromotive force and resistance determined by Ohm. This law states that the current varies directly as the electromotive force, and inversely as the resistance of the circuit. Usually known as *Ohm's law.*

Law of Reflection.—The angle of incidence and the angle of reflection are in the same plane and are equal.

Law of Volta.—A law of the difference of potential between the metals in a contact series. It may be stated as follows: the difference of potential between any two metals is equal to the sum of the differences of potentials between the intervening metals in the contact series. Usually called *Volta's law.*

Laws of Electrical Resistance.—Resistances in a circuit may be of two kinds —*first,* the resistances of the conductors themselves; *second,* the resistance due to imperfect contact at points. The latter kind of resistance is affected by pressure, for when the surfaces of two conductors are brought into more intimate contact with one another, the current passes more freely from one conductor to the other. The following are the laws of the resistance of conductors:

1. The resistance of a conducting wire is proportional to its length. If the resistance of a mile of telegraph wire be 13 ohms, that of fifty miles will be 50 × 13 = 650 ohms.
2. The resistance of a conducting wire is inversely proportional to the area of its cross section, and therefore in the usual round wires is inversely proportional to the square of its diameter. Ordinary telegraph wire is about $\frac{1}{6}$th of an inch thick; a wire twice as thick would conduct four times as well, having four times the area of cross section; hence an equal length of it would have only $\frac{1}{4}$th the resistance.
3. The resistance of a conducting wire of given length and thickness depends upon the material of which it is made; that is to say, upon the specific resistance of the material.

Laws of Electrolysis.—The number of ions liberated in electrolysis at either pole is proportional, 1st, to the amount of electricity passing through the circuit, and 2d, to the electrochemical equivalent of the ion, that is, its atomic mass divided by its valency in the compound electrolyzed. Also known as *Faraday's laws.*

Laws of Electromagnetic System.—1. *When a magnet is placed near an electric circuit, every portion of the circuit is acted upon by a force urging it in such a direction as to make it enclose within its embrace the greatest possible number of lines of force.* (Maxwell's rule.)

2. *Every electromagnetic system tends to change the configuration of its parts so as to make the flux of magnetic lines through the exciting circuit a maximum.*

Laws of Faraday.—The laws of electrolysis, so named from Michael Faraday who discovered them.

Laws of Heat.—Heat is transmitted in three ways: (a) by conduction, as when the end of a short rod of iron is placed in a fire, and the opposite end becomes warm, this is conducted heat; (b) by convection, such as the warming of a mass of water in a boiler; and (c) by radiation, as that diffused from a piece of hot metal or an open fire. Radiant heat is transmitted, like sound or light, in straight lines in every direction, and its intensity diminishes inversely as the square of the distance from its center of radiation.

Laws of Thermodynamics.—The theory of heat considered as a form of energy, is

useful in advanced studies of the theory of steam, gas, air engines, etc. The first two laws of thermodynamics are as follows:

1. *Mechanical energy and heat are mutually convertible in the ratio of about 778 foot pounds for the British thermal unit.* (Joule: originally 772 foot pounds.)

2. *A self-acting machine, unaided by any external agency, cannot convert heat from one body to another at a higher temperature.* (Clausius.)

Lay.—To place in order; to arrange with regularity; to dispose in ranks and tiers; as, to lay bricks or stones in a wall.

Layer.—1. That which is laid; a stratum; a body spread over another; as, a layer of clay or of sand; a course; as, of bricks and the like.

2. In electroplating, a metallic deposit laid over another metallic surface.

Laying Out.—1. The method or process of arranging a scheme of work so that the processes shall follow one another in due order.

2. The act of scheming the arrangement for a plant installation so that the desired end may be best attained.

Laying Up Cables.—The process of making up cables by stranding together separate wires or conductors.

Lay of Wires.—The manner in which wires are caused to make a complete twist about a central core or axis.

Layout.—The general arrangement of anything, as a works or plant; the method of carrying on operations; the scheme or system planned for effecting any desired result.

Lead—1. An insulated conducting wire which leads from an electric source to any main, feeder, station, instrument, circuit, etc.; in general, one of the conductors in a system of electric distribution.

2. In a steam engine, the amount of preadmission given by the slide valve at the instant the piston is ready to commence its impulse stroke. The amount varies and depends upon the type of engine and the angular advance of the eccentric.

Lead.—A lustrous, blue gray metal, soft enough to be cut with a knife or to leave a mark on a piece of paper: it is malleable and ductile, but is not a good conductor of heat and electricity as compared with other metals, Its specific gravity is 11.2, a cubic foot weighing 698 lbs.; its tenacity is about 2,600 lbs. per square inch as wire.

Lead Accumulator.—A storage cell consisting of lead plates immersed in dilute sulphuric acid.

Lead and Lag.—In the case of alternating currents, the amperes and volts do not always keep step with each other. If there be inductance in the circuit, the currents will *lag* in phase; if there be capacity, they will *lead*. Inductance also has the effect of choking down the current; that is, while the intensity of the current is on the increase, the reactive effect of inductance tends to prevent its rising.

If an alternating current of C virtual amperes flows with a frequency of n cycles per second through a circuit of inductance L, the reactive electromotive force is:

$$2\pi n \text{ LC virtual volts.}$$

Lead Bath.—The solution employed in lead plating. Two principal solutions are recommended, viz.: (a) Dissolve by boiling 1.75 oz. caustic potash and 0.17 oz. pulverized litharge in 1 qt. of water; (b) acetate of lead 0.17 oz., acetic acid 0.17 oz., and 1 qt. water.

Lead Burning.—A method of joining two plates or strips of lead by fusing them together at their line of junction by the heat of a hydrogen flame, a process by which the lugs or terminals of the separate cells in a storage battery are connected.

Lead Covered Cable.—An underground cable protected by a covering of lead outside the insulation.

Lead Covered Conductor.—A conductor protected by a sheathing of lead over the insulation.

Leaded Cable.—A lead covered cable.

Lead Hammer.—A hammer with a head of cast lead used for striking polished work. In engineering work, it is customary to employ hammers of copper, white metal or babbitt and lead, thus affording various degrees of hardness, according to the strength of the blow required to be struck.

Leading Block.—A block for guiding a rope, as a purchase, or for hauling an end out of a direct line.

Leading Current.—An alternating current having a lead in phase in advance of the electromotive force impressed upon the circuit.

Leading E. M. F.—In an alternating current circuit, if the electric motive force reaches its maximum value a fraction of a period before the current, it is said to lead the current by an amount measured by the equivalent angle.

Leading Horns.—The projecting edges of the pole pieces of a dynamo which extend in the direction corresponding to the rotation of the armature; the poles away from which the armature turns.

Leading In Insulator.—An insulator for supporting the leading in wires from an overhead circuit into a building.

Leading In Tube.—An insulating tube for the protection of leading in wires as they are admitted to a building.

Leading In Wires.—1. Wires leading from an overhead circuit into a building.

2. The wires that make the connection between the filament of an incandescent lamp and the electric circuit.

Leading Poles.—The projections of the pole pieces of a generator which extend in the direction of the rotation of the armature; the *leading horns.*

Leading Up Wires.—Wires by means of which an overhead cable is raised to the cable hangers for support.

Lead Joints.—In pipe fitting, lead joints are used in pipe connections. Sometimes a sheet of lead is screwed up between flanges, but the employment of the metal is more common in *socket and spigot* joints. The lead is poured between the socket and spigot and hammered or stemmed down; that is, driven closely home with a drift and hammer.

Lead Monoxide.—Commonly called *litharge.* A substance employed for the active material of storage battery plates, especially for pasting the negative plate in the Faure type of cell.

Lead of Brushes of Dynamo.—In order to prevent sparking at the commutator, a position of the brushes upon its surface a little in advance of the diameter between the poles; being a *positive* lead.

The necessity for the lead arises from the counter magnetism or the magnetic reaction of the armature. In magnetism the tendency of hard iron, or steel especially, is the cause of the "lag" or magnetic retardation. It is to accommodate this variation that brush holders are provided with devices for moving them backward and forward.

Lead of Brushes of Motor.—In order to prevent sparking, a position of the brushes upon a motor commutator a little back of the diameter between the poles; being a *negative* lead.

Lead of Current.—When the capacity of an A. C. circuit is more effective than the induction the current leads the pressure.

Lead of Ignition or Spark.—In an internal combustion engine, ignition which takes place before the piston has finished its compression stroke. When the mixture is fired after the piston has started on its downward stroke it is said to have a negative lead. The word "advance" is usually used instead of lead.

Lead Peroxide.—The lead compound employed to form the positive plate of a storage battery cell. It has a reddish brown or chocolate appearance in the cell.

Lead Plating.—Depositing a layer of lead upon an object by electroplating, generally as a protection against the action of mineral acids, as when gun barrels are coated with lead peroxide to prevent rust.

Lead Scorer or Scraper.—A triangular tool for scraping a lead covered conductor, or other lead surface, so that the metal may be clean and bright preparatory to making a joint.

Lead Sheathing.—A covering of lead applied to a cable in order to protect it from injury when underground.

Lead Sleeve.—A sleeve of lead fitted over a joint in a lead covered conductor.

Lead Sponge.—The condition of the plates of the Planté type of storage cell after the "forming" process by which the metallic lead of the plates is made spongy or porous. In the Faure type, the active material of the negative plate becomes lead sponge after being exposed to electrolysis.

Lead Sulphate.—A chemical compound which is formed upon discharging a storage battery by an action called sulphatation in which the lead oxide, PbO, is changed into lead sulphate by the sulphuric acid of the electrolyte. It is a white substance, possessing a high resistance, and tends to destroy the activity of the cell.

Lead Sulphate of Copper Cell.—A storage cell composed of electrodes of lead in a solution of copper sulphate.

Lead Sulphate of Zinc Cell.—A storage cell composed of electrodes of lead in a solution of zinc sulphate.

Lead Tin Alloy.—A combination of lead and tin, making an alloy which will melt at a low temperature, and hence is suitable for safety fuses. For example, an alloy of one part tin, and one of lead, will melt at 370° to 466° F.

Lead Tree.—A branching deposit of lead crystals resembling a tree, produced by the electrolysis of a lead salt in solution.

Lead Voltameter.—A voltameter having electrodes of lead in a dilute solution of sulphuric acid.

Leak.—1. The escape, as of a fluid, by leaking.

2. The dissipation of electricity through faulty insulations.

3. The defective point at which leaking takes place.

Leakage.—1. The escape, as of a fluid, by leaking; a leak.

2. The escape of electric current through defects in insulation or other causes. A certain amount of magnetic flux escapes through the air in operating dynamos. It is this leakage flux which affects watch springs in the vicinity of electric generators.

No matter how well insulated a charged conductor may be, or how dry the atmosphere, the conductor slowly loses its charge, and in a few days the dissipation of the charge is complete.

The rate of discharge depends upon the difference of potential between the charged conductor and the surrounding medium, hence, the discharge is more rapid at the beginning than afterwards. If the pressure be measured at equal intervals, it will be found to have diminished in a decreasing geometric series. For a negatively electrified conductor, the rate of discharge is greater than for one positively electrified.

Leakage Conductance.—The reciprocal of leakage or insulation resistance; *leakance.*

Leakage Conductor.—In a telegraph circuit, a conductor providing a direct path to earth for leakage currents in order to prevent their interfering with neighboring lines.

Leakage Drop.—The fall of potential in an electric circuit due to leakage.

Leakage, Electric.—The dissipation of the electricity of a charged body, or the escape of current from a conductor, due to insufficient or faulty insulation.

Leakage Factor.—The ratio of the total electromagnetic flux entering the cores of the dynamo field magnets, to the available flux entering the armature.

Leakage Flux.—The electromagnetic flux which fails to enter the armature of a dynamo to do useful work, being dissipated from the field magnets.

Leakage Indicator.—An instrument for detecting leakage in an electric circuit: *a magnetic explorer.*

Leakage Interference.—Interference arising between neighboring electric currents as the result of leakage between them.

Leakage, Magnetic.—The stray lines of magnetic force which leak around a dynamo armature, instead of passing through it.

Leakage Method of Measuring Insulation.—A method of determining the degree of insulation by measuring the leakage from an insulated body.

Leakage of Steam.—Except in rare cases, the leakage of steam in an engine cylinder has so little effect upon the lines of an indicator diagram that it can scarcely be detected. For this reason the true water consumption of an engine is best ascertained by a feed water test. When the expansion line of an indicator diagram departs much from the hypobolic curve, the extent of the losses due to leakage and condensation is more accurately computed at cut off than at release.

Leakage Paths.—The paths followed by the flow of magnetic leakage.

Leakage, Photo-electric.—According to Hertz, a spark starts between the balls of a discharger more rapidly when illuminated by light that is rich in violet and ultra-violet rays, than when not so illuminated. In ultra-violet light freshly polished zinc in air rapidly discharges a negative charge, but not a positive one. The effect appears to be due to the small light waves stimulating chemical reactions which do not occur except by a species of electric exchange. Clean zinc plates were positively charged by Hallwachs by exposure to ultra-violet light.

Leakance.—The reciprocal of leakage, or insulation resistance; also called *leakage resistance.*

Leat.—In hydraulics, a channel for water dug on the ground level; it differs from the

launder in that the latter is an artificial conduit carried at a slight elevation above the ground.

Leather.—The skin of an animal converted into a durable and non-decaying substance, which is soft and supple for certain uses, firm and hard for others. There are three main processes: (1) Impregnation of the hide or skin with tannic acid which combines with the gelatine to make an insoluble substance, this being used for sole leathers and the like; (2) treatment with alum or other mineral salts; as, for glove skins; (3) treatment with oils and fats; as, for chamois skins (*shamoying*). Heavy leathers are also tanned with *chrome*, principally for belting.

Leather Belting.—A material widely used for driving machinery. It is used single or double, sometimes treble for a main drive, the thickness of each single strip ranging from $\frac{5}{32}$ inch to $\frac{5}{16}$ inch. The strips are spliced, cemented, or sewn together to make up the necessary length and width, and are finally united at the ends by lacing, cementing or riveting. The ultimate stress of leather belting is 3000 to 5000 lbs. per square inch of section. For a single belt the usual working load is 33 lbs. per inch of width.

Leathers.—In hydraulics, cup or hat leathers as used in pumps or hydraulic presses.

Leclanché Cell.—An open circuit cell used to a great extent in telephone work and with electric bells; it has a negative electrode consisting of carbon and peroxide of manganese, a positive electrode of zinc, and an electrolyte composed of a solution of sal ammoniac. This cell polarizes quickly, but on open circuit it slowly recovers its working condition.

In the operation of the cell the chemical reaction which takes place is as follows: The zinc becomes oxidized by the oxygen from the manganese peroxide, and is subsequently converted into zinc chloride by the action of the sal ammoniac. After the battery has been in continuous use for some hours, the manganese becomes exhausted of oxygen, and the force of the electrical current is greatly diminished; but if the battery be allowed to rest for a short time, the manganese obtains a fresh supply of oxygen from the atmosphere, and is again fit for use. After about 18 months' work, the glass cell will probably require recharging with sal ammoniac, and the zinc rod may also need renewing; but should the porous cell get out of order, it is better to get a new one than to attempt to recharge it.

Leclanché, Georges.—Born 1839, died 1882. A French chemist, inventor of an important type of voltaic cell known as the Leclanché cell (1868).

Lecture Galvanometer.—A galvanometer suitable for exhibiting its operations to a lecture audience.

Left Hand.—A term applied to many objects as a classification to denote their arrangement, position or motion.

Left Handed Armature Windings.—Windings applied to an armature in a direction opposed to the movement of the hands of a clock as seen from the face.

Left Handed Dynamo.—A dynamo rotating in a counter-clockwise direction as seen from the pulley.

Left Handed Helix.—A coil or solenoid wound in a counter-clockwise direction; a sinusoidal helix or solenoid.

Left Handed Motor.—A motor which rotates in a counter-clockwise direction as seen from the pulley.

Left Handed Rotation.—Movement of a rotating body in a direction from right to left, or in the opposite direction of the hands of a clock as they are seen to move when one reads the time; counter-clockwise rotation.

Left Handed Solenoid.—A left handed helix.

Left Handed Spiral.—A left handed helix.

Left Handed Winding.—Winding, as of armature coils, in a counter-clockwise direction.

Left Hand Engine.—In steam engineering, an engine having its fly wheel to the *left* when viewed from the *cylinder*.

Left Hand Screw.—In machinery, a screw which *enters* in turning from right to left; *i. e., counter-clockwise.*

Left Hand Thread.—A helix, or spiral, whose turns, when viewed sidewise, curve from left to right in their course from the bottom to the top, necessitating a counter clockwise turning movement when entering a nut: both motions being the reverse of those with the ordinary thread.

Left Hand Trolley Frog.—A trolley frog for guiding a trolley wheel to the wire on the left of the main wire.

Leg.—1. That which resembles a leg in form or use; especially any long and slender support on which any object rests; as, a leg of a pair of compasses.

2. In a telephone exchange, a branch wire employed to bring an operator's

instrument into direct connection with two or more subscribers.

Legal Ohm.—The value of the ohm as defined by the electrical congress, held in Paris in 1884, as the resistance of a column of pure mercury, one sq. millimeter in section, 106 centimeters long, at a temperature of 0° C; the *international ohm.*

Legal Quadrant.—The value of the quadrant as fixed by the electrical congress of 1884 in Paris.

Legged.—Connected with a main circuit by means of a branch wire.

Legging Keyboard.—In a telephone exchange, a keyboard for directly connecting an operator with two or more subscribers.

Leg Key.—A telegraph key provided with a screw projecting from its base by which it may be secured to a table.

Legless Key.—A telegraph key without a screw base.

Leg of Circuit.—1. A branch or lateral circuit connected with the main circuit.

2. One of the leads of a metallic circuit.

Leg of Electromagnet.—One of the limbs of the iron core of an electromagnet.

Lenard Effect.—The effect produced by Lenard in passing cathode rays out into the air through an aluminum "window" in a Crookes tube.

Lenard, Philipp Eduard Anton.—Born 1862. A German physicist, distinguished for his experiments with *cathode rays.*

Lenard Rays.—The cathode rays caused by Lenard to pass through an aluminum window in a Crookes tube.

Lenard Tube.—A variety of Crookes tube having a piece of aluminum sealed into the glass at the end opposite the cathode, thereby forming a "window" through which Lenard rays can pass.

Length of Spark.—The width of the spark gap or the sparking distance between the terminals of an induction or spark coil, being the distance through air that the disruptive discharge can take place, varying as the difference of potential and the pressure of the air.

The length of spark increases with the electric pressure. It diminishes with an increase of air pressure, hence, the high voltage required for ignition of internal combustion engines (10,000 to 30,000 volts) due to the compression of the fuel mixture. The length of spark varies for different gases, for instance, it is nearly twice as long in hydrogen as in air at the same density. The voltage required to produce a given length of spark depends on the shape of the electrodes and not on the kind of metal used. Pointed electrodes produce the longest spark with a given voltage.

Faraday, using two spheres of different sizes as electrodes, found the spark length greater when the smaller sphere was positive than when it was negative.

A perfect vacuum is a perfect insulator; no spark will cross it.

Lens.—A portion of a transparent medium, usually glass, having one or more curved faces for the purpose of causing rays of light to converge or diverge in passing through it.

Lens Lamp.—An incandescent lamp having a lens sealed into one side of its bulb for focusing the light.

Lens Mirror Projector.—A device for projecting light by the joint action of a lens and a mirror.

Lenz's Law.—The law, first stated by Lenz, a German physicist, that, in electromagnetic induction, the direction of the induced current is such as to oppose the motion producing it.

Lesser Calorie.—The calorie, as distinguished from the *greater calorie.*

Let In.—A shop term, which signifies the sinking in of one portion of wood or metal into another. Thus, rapping plates are *let in* to patterns, brass rings are *let in* to sluice cocks, faces, etc.

Letter Box, Electric.—An electric device attached to a letter box to indicate that a letter has been deposited in it.

Letter Printing Instrument.—The instrument used in printing telegraphy.

Level.—1. Lying in a horizontal line or plane.

2. The average elevation of a certain place, as sea *level.*

3. The altitude or elevation of a definite spot, as compared with some standard or *datum line*, generally the mean level of the sea.

4. An open channel along which water flows.

5. A horizontal excavation in a mine or along the course of a vein of ore.

6. A surveying instrument for determining the relative heights of two points. It has a telescope capable of accurate horizontal adjust-

ments, and mounted upon a tripod stand. The level is used in conjunction with a graduated staff, which is held vertically on various successive stations. The marks on the staff which coincide with the cross wires of the telescope at each point, are carefully observed, and their difference corresponds to the difference in elevation of the various points.

Level, Electric.—The state of an electrified surface in which there is no difference of potential.

Level of Earth, Electric.—A term referring to the electricial potential of the ground.

Lever.—A bar of metal, wood, or other substance, used to exert a pressure, or sustain a weight, at one point of its length, by receiving a force or power at a second, and turning at a third on a fixed point called a fulcrum. It is usually named as the first of the six mechanical powers.

There are three kinds of levers, viz.: (1) Those in which the fulcrum lies between the points at which the force and weight act; (2) those in which the weight acts at a point between the fulcrum and the force; and (3) those in which the force acts at a point between the weight and the fulcrum. The distances between the fulcrum and the weight and force are called the *arms*.

The relation between the force exerted or the pull, P, and the weight lifted or resistance overcome, W, is expressed by the equation:

$$P \times a = W \times b$$

in which, a is the lever arm of P, and b is the lever arm of W.

Leverage.—The mechanical power gained by the employment of the lever.

Lever Brake.—A car brake controlled by a lever.

Lever Hook.—A hook upon which a telephone receiver is hung, moving a lever which cuts the instrument out of the circuit; when the receiver is lifted off the hook the lever acts to complete the circuit again.

Lever Jack.—In machine shop work, a form of jack comprising a simple lever for lifting, and a standard for support.

Lever Switch.—Any switch turning upon a fixed axis like a lever.

Lewis.—In stonework, a device for lifting blocks, in which two wedge shaped pieces are inserted in a dovetailed recess, centrally disposed, and locked by a center tongue piece. The whole is fastened with a shackle or chain, so that the lewis wedges itself tight on the dovetail in lifting.

Lewis Bolt.—A bolt for securing into stonework, similar to the lewis, having a pyramidal head, which is permanently fastened in the dovetail by pouring melted lead around it.

Lewis Plug.—A device for lifting stones, consisting of a tapering plug fitted into a slightly larger conical hole over the center of gravity. A key is driven in between the plug and the circumference of the hole, holding all tight under strain, but released by a downward tap when the block is landed.

Leyden Jar.—A simple form of condenser consisting of a glass jar coated inside and out to a certain height with tinfoil, having a brass rod terminating in a knob passed through a wooden stopper, and connected to the inner coat by a loose chain. It receives its name from Leyden, the city in which it was invented.

Leyden Jar Battery.—Several Leyden jars grouped together so as to form a battery.

Leyden Jar Discharge.—1. The disruptive discharge from a Leyden jar.

2. An oscillating discharge derived from a Leyden jar.

Lichtenberg's Dust or Electric Figures.—A method of investigating the distribution of electricity devised by Lichtenberg. It consists of sifting a mixture of powdered red lead and sulphur upon a sheet of pitch or dry glass, the surface of which has been rubbed by the knob of a Leyden jar; the powder then assumes curious forms illustrative of the electrification.

Life.—1. In mechanics, the period of time during which an object may be kept in actual use; as, the *life* of an incandescent lamp.

2. The number of separate times which an object may be used that is designed not to be employed continuously.

Life Curve of Incandescent Lamp.—A characteristic curve showing the durability of an incandescent lamp in hours by abscissas, and the rate of burning in candlepower by ordinates.

Life of Cell.—In storage battery practice, the durability of the plates for good service.

This depends largely upon the care in handling and upkeep, and the extent of use.

Life of Incandescent Lamp.—The length of time, expressed in hours, during which an incandescent lamp gives satisfactory light under normal conditions.

Lift.—1. To move in a direction opposite to the law of gravitation; to raise; to elevate.

2. The space or distance through which anything is lifted.

3. A hoisting machine; an elevator.

4. In mechanics, one of the steps of a cone pulley.

5. In mining, a single set of pumps in the shaft; each combination of pumps and cistern, of which a series are used to raise the water to the surface.

6. In pumping, that portion of the *total head* represented by the difference in elevation of the water to be pumped and the inlet valves of the pump.

Lift and Force Pump.—In hydraulics, one which sucks or lifts the liquid to be pumped, and delivers the same under pressure. To effect this, some sort of piston or plunger pump is necessary.

Lift, Electric.—An electric elevator.

Lifting Jack.—A screw, ratchet or hydraulic jack, designed to raise heavy weights.

Lifting Magnet.—A large electromagnet designed for lifting purposes in handling scrap, pig iron, rails, plate, etc. It consists essentially of a copper coil embedded in an outer casing of cast iron or steel. The lifting power depends both upon the form of the magnet and on its magnetic strength. A horseshoe magnet will lift a load three or four times as great as a bar magnet of the same weight.

The lifting power is greater if the area of contact between the poles and the armature be increased. Also the lifting power of a magnet grows in a very curious and unexplained way by gradually increasing the load on its armature, day by day, until it bears a load which at the outset it could not have done. Nevertheless, if the load be so increased that the armature is torn off, the power of the magnet falls at once to its original value. The attraction between a powerful electromagnet and its armature may amount to 200 lbs. per square inch.

Small magnets lift a greater load in proportion to their own weight than large ones. A good steel horseshoe magnet weighing itself one pound ought to lift twenty pounds weight. Sir Isaac Newton is said to have possessed a lodestone mounted in a signet ring which would lift a piece of iron 200 times its own weight.

Lifting Valves.—Those in which the disc or cone is lifted vertically from the seat, by pressure from below, as in *safety valves*. Also poppet or double beat valves which have vertical motion.

Light.—That form of radiant energy which affects the eye so that objects become visible.

Light Bath, Electric.—In electro-therapeutics, a form of treatment in which the invalid is exposed to the rays from incandescent lamps.

Light, Electric.—Light produced by the passage of an electric current. A current of ten amperes at forty-five volts is usually required for direct current open arc lights. The pressure range ordinarily being from forty-two to fifty-two volts. A 450 watt arc, as above, is usually rated at 2000 candle power, and a 300 watt arc, at 1200 candle power. Current for arc lighting may be furnished by (1) series, (2) constant current, or (3) by the parallel constant pressure system. The circuit voltage of the latter system is usually 110, two lamps being connected in series Enclosed arcs consume about five amperes at eighty volts; when alternating current is used they consume six amperes at seventy to seventy-five volts. Incandescent lamps take from three to four watts per candle power.

Light Escape.—A term indicating a partial escape of electricity to earth.

Lighthouse Illumination.—The illumination of lighthouses by the use of focusing electric arc lamps.

Light Indicator.—A form of electric annunciator employed to indicate whether a railroad signal lamp is lighted or not.

Lighting Circuits.—Circuits for maintaining a system of electric lights.

Lighting Mains.—In an electric lighting system of house wiring, the conductors which are prolongations of the "feeders." They run from the outside lines to the distribution center.

Light Load.—As applied to a dynamo, a delivery of current much less than it is capable of delivering.

Lightning.—A discharge of atmospheric electricity, exhibited in flashes of various types taking place between the clouds and the earth, or between neighboring clouds. There are many forms of lightning, such as ball, chain, forked, globular, zigzag, etc. It has been estimated that the pressure required for a lightning flash a mile long would be over three and one half million volts. Zigzag light-

ning resembles the spark from an electric machine. If a disruptive discharge should pass through a living animal it is often fatal. As a discharge reaches the earth, the heat is sufficient, sometimes, to fuse sand.

Lightning Arrester.—A device connected with electric apparatus for carrying a lightning discharge to earth, and thus protecting instruments and operators from injury.

One form of lightning arrester used in connection with telephones, is known as the carbon arrester and consists of two flat blocks of carbon, between which is placed a thin sheet of mica. Such pairs of carbon blocks are attached to each terminal of the line, one on each being connected to line, the other to ground. The direct line to the telephone apparatus is, however, not broken on either limb, the carbons forming a branch circuit. The theory is that the lightning current will pass through the small hole in the mica strip between the carbon blocks, and follow the line of least resistance to ground. In practice, this theory seems amply warranted.

A further protective feature is sometimes introduced, consisting in not only perforating the mica plate at a point midway on its length, but also inserting in a hole in one of the blocks a small drop of fusible metal. Under a high heat pressure this metal will melt, thus assuring perfect electrical connection between the two blocks, and grounding the line. The fuse and carbon protectors are frequently combined in one instrument, thus assuring complete protection to the apparatus from all electrical disturbances.

Lightning Arrester Board.—In a telephone or telegraph system, a board for carrying the lightning arresters.

Lightning Arrester Earth.—The earth to which a lightning discharge is conveyed by a lightning arrester.

Lightning Bolt.—The flash of a discharge of lightning.

Lightning Conductor.—A lightning rod; also called *lightning guard.*

Lightning Deviator or Discharger.—A name sometimes given to a lightning arrester.

Lightning Jar.—A Leyden jar coated with metallic filings which exhibit scintillating sparks when the jar is discharged.

Lightning Rod.—A conducting rod or cable erected on the outside of a building and connected to earth, in order to afford protection from lightning by carrying the lightning discharge into the ground; or to prevent lightning by leading the electricity from the earth to the cloud without disturbance.

Lightning Stroke.—A discharge of lightning from the clouds to the earth.

Lightning Tube.—A fused tube produced in sand, earth or rock by the action of lightning. Also called *fulgurite.*

Lignite.—In mining, mineral coal retaining the texture of the wood from which it was formed, and burning with a disagreeable odor; called also *brown coal* and *wood coal.*

Lignum Vitæ.—A wood found in Cuba, Jamaica and San Domingo. It is of a dull, brownish green color, hard, and close grained; the fibers interlacing at various angles. The heart wood is chiefly used, and its uses in engineering are for the linings of the shaft bearings of propeller screws and turbines, which work in and are lubricated by water only. It is also greatly used for making of mallets, etc. A cubic foot weighs from 40 to 80 lbs.

Lillie Wire Joint.—A method of joining wires in which the connector consists of a strip of copper curved longitudinally in opposite directions, the wires being slipped into the curved channels and twisted in opposite directions.

Lime.—Oxide of calcium; the white, caustic substance, usually called quicklime, obtained from limestone, shells, etc., by heat, the heat expelling carbonic acid and leaving the lime behind.

Lime Light.—The oxyhydrogen flame or calcium light. Hydrogen burns in air with a non-luminous hot flame. If it burn in combination with oxygen instead of with air, the heat is greatly intensified. By allowing this flame to impinge upon a small cylinder of lime (calcium oxide) an exceedingly brilliant light results.

Limestone.—A kind of stone consisting largely or chiefly of carbonate of lime, from which lime is obtained by the expulsion of its carbonic acid. Limestone is much used as a building stone, but most frequently is calcined in lime kilns, in which the carbon dioxide is driven off, and the oxide of calcium, an alkaline earth termed quick lime remains. This is used to a great extent in manufactures and the arts. For use as mortar it is "slaked" with water, which it absorbs with avidity, accompanied by an increase in volume, and the liberation of heat.

Limewhite.—Whitewash; a mixture of quicklime and water, used for rough painting, especially in places where a frequent application is necessary. It may be improved for holding on metal by adding 1 lb. of tallow to 10 gallons of wash, or may be made weather proof by adding 12 lbs. of salt to the same quantity.

Limit Gauges.—Double ended gauges, those for external work being stamped "go on" or "not go on" at either end, those for internal work bearing the lettering "go in" and "not go in"; the two ends are also of different shape for easy recognition. Each end is made to a certain allowance above or below the nominal standard size according to the degree of finish required, thus fixing the limits of the variation between the maximum and minimum sizes of a hole or shaft. By their use, the time spent in gauging and measuring is reduced to a minimum, and interchangeable work is easily produced, the limits of variation being easily controllable.

Limiting Distance of Speech.—In a telephone line, the extreme distance over which conversation can be satisfactorily heard, depending upon the capacity of the circuit and the instruments used.

Limiting Speed of Cable.—The extreme speed of cable transmission, limited by the resistance and electro-static capacity of the line.

Limiting Stop.—A stop for fixing the distance of any swinging motion, or vibration, within definite limits.

Limiting Temperature.—The extreme limits of temperature which an apparatus can safely bear without suffering injury.

Limit Switch.—In an electric elevator, a switch automatically operated by the car for opening the circuit and limiting the travel of the car.

Line.—In general, a conducting wire between stations in a system of electric communication or distribution.

Line Adjuster.—In a telegraph line, a device for adjusting relays to counteract the effects of leakage.

Linear Capacity.—A quantity equal to the capacity of a conductor divided by its length.

Linear Capacity of Cable.—The ratio between the electro-static capacity of a cable and its length.

Linear Density, Electric.—The quantity of electricity upon a charged surface considered in relation to the length of the surface.

Linear Insulation.—The insulation of a conductor considered in relation to its length.

Linear Insulation of Cable.—The insulation resistance of a cable considered in relation to the length of the cable.

Line Arrester.—A lightning arrester in the circuits of a telegraph or telephone line.

Line Battery.—In telegraphy, the battery often called the *main* battery which is used in operating the main line, as distinguished from the *local* battery.

Line Circuit.—The conductors which form the main line in telegraph, telephone and electric distribution circuits; the main circuit.

Line Crosses.—Accidental electric connections between overhead lines.

Line Drop.—An annunciator drop in a telephone switchboard.

Line Dynamometer.—A form of dynamometer used in overhead line construction to obtain the proper degree of tension in a wire; *a tension ratchet.*

Line Insulator.—An insulator carrying an overhead line.

Line Jacks.—The spring jacks of a telephone switchboard connected with subscribers' lines.

Lineman.—An electrician employed to put up line circuits, and to see that all the parts are kept in proper condition.

Lineman's Detector.—A portable galvanoscope used by linemen in tracing circuits and localizing faults in the erection and repair of telegraph lines or other electric circuits.

Line of Least Sparking.—That diameter of a dynamo or motor commutator at which the brushes may rest with little or no sparking.

Line Peg.—The connecting plug in a telephone switchboard.

Line Pressure Compensator.—In an alternating current system, a compensating device attached to a voltmeter by means of which allowance is made for a fall of potential in a feeder.

Line Reactance.—The reactance existing in a conducting line.

Line Section of Electric Railroad.—A section of an electric railway system so related to the rest of the parts, as to allow of its having control over its own power.

Line Shafting.—Shafting arranged in a line; as, in a factory, taking its power from one point and distributing it by means of belts and pulleys to the various machines on either side of its length.

Lines of Electric Displacement.—The assumed lines of electric flow which are associated with electric displacement.

Lines of Electric Induction.—The assumed lines of direction along which electric induction moves in a conductor.

Lines of Electrostatic Flux.—The assumed lines of direction followed by electrostatic flux.

Lines of Electrostatic Force.—Assumed lines of force existing in the vicinity of an electrified body in the direction followed by electrostatic attraction and repulsion; also called *lines of inductive action.*

Lines of Force.—In any "field" such as that produced around and inside a coil of wire through which a current flows, or between the poles of any magnet either electrical or permanent, there are *invisible lines of force* which arrange themselves in a definite shape around and between the poles, and if they be cut in any way by moving a wire across them, a current is produced in the wire and this current depends largely upon the number of these lines of force which are cut per second. It makes no difference whether the wire be held stationary and the magnet and its field moved, or whether the wire itself is moved and the field is stationary. The result is the same as far as producing a current is concerned. The utilisation of this principle is the basis upon which the mechanical producers of electricity, such as dynamos and magnetos, are made.

Lines of Magnetic Force.—Lines assumed to exist in a magnetic field of force, tracing the paths along which magnetism acts. If a thin piece of paper be placed over a bar magnet and fine iron filings be sprinkled over it, the particles of iron will arrange themselves in regular curves between the poles and map out or define lines in the magnetic fields which scientists call lines of force.

The forms of the curves show not only the direction of the magnetic force, but they also enable us to draw conclusions as to its intensity. When the force is great the curved lines are thick and sharply defined, and when it is weak the lines are thin and less plain.

The lines of force are also to be found in the neighborhood of wires through which electric currents are passing. They are the outward effect produced by the passage of an electric current, but the most singular fact is that they can also be the cause of an electric current.

Lines of Magnetic Induction.—The assumed lines of direction along which magnetic induction moves in a body; also called, *lines of magnetization.*

Line Spectrum.—A spectrum of light consisting of more or less sharply defined lines which are arranged without any apparent regularity.

Line Wire.—The conducting wire between stations in a telegraph or telephone system.

Line Wire Tier.—A short binding wire by which a line wire is tied to an insulator.

Link.—1. One of the rings or separate sections of which a chain is composed.

2. That which connects any one thing or part with another, or any individual member of a connected series forming a continuous whole.

Linkages.—The linking together of lines of magnetic force and the conducting coils through which they pass; the total number of linkages being the product of the magnetic flux by the number of turns in the coil.

Link Bolting.—This consists of a number of short links, arranged parallel for power transmission. They are retained in position by pins which permit the links to pivot freely and bend around small pulleys and transmit power easily between those which are situated at a short distance apart, being more flexible than continuous belting.

Link Fuse.—A safety fuse containing a link of fusible material.

Link Insulator.—A form of insulator for high tension transmission lines, consisting of a number of porcelain discs held together by wire and links and hung from the cross arm. The line wire is attached to the side or top by tie wires.

Link Shoe.—In electric traction, a form of third rail contact shoe which is suspended by two links from the yoke bolted to the shoe beam.

Liquefaction.—The reduction of solids to a liquid state by means of heat or solution; and of gases by cold, or pressure, or both.

Liquid.—Anything which flows and can be poured in drops, like water; it differs from a *fluid* in that the latter flows in a stream or streams, as a gas. Another definition is that a liquid flows and wets that on which it flows.

Liquid Air.—A dry colorless liquid obtained by subjecting atmospheric air to great pressure and abstracting its heat.

Liquid Compass.—A standard type of mariner's compass in which the bowl is filled with a mixture of alcohol and water which serves to overcome the effect of vibration upon the needle.

Liquid Damping.—A method of damping the swing of the needle of a measuring instrument by fluid friction. Oil damping is commonly used when moving parts are heavy, a rotating paddle turning against the oil in which it is immersed.

Liquid Fuel.—Petroleum burnt in suitable furnaces in the form of a spray is superior to ordinary coal as fuel, having thirty-three per cent. higher evaporative value than anthracite. It is more easily stored and transported, and yields no ashes in combustion.

Liquid Level Alarm.—An electric alarm given by the action of a float upon a make and break mechanism, when a certain liquid falls below or exceeds a given level; a water level alarm.

Liquid Lightning Arrester.—A form of lightning arrester sometimes employed in water power plants in which either a jet of water is played upon a conductor connected to the line, or a column of water contained in an insulated pipe is connected at one end to the line and the other to earth. The former type is usually known as the *water jet arrester*.

Liquid Resistance.—Pure water is sometimes employed for the control of the electric current. The water is usually contained in a wooden box called the "water box." Metal terminals are immersed in the water and the resistance is adjusted by varying the degree to which the terminals are immersed or by changing the distance between them. Liquid resistances are often convenient in connection with electrical testing.

Liquids as Conductors.—With respect to the conducting properties of liquids, they may be divided into three classes: (1) Those which are non-conductors, as turpentine, petroleum and many oils, (2) those which conduct without decomposition, as mercury; (3) those which conduct and are decomposed, as dilute acids and solutions of metallic salts, etc.

Liquid Thermostat.—A thermostat which acts by the expansion of a liquid when heated.

Listening Key.—A key or cam controlled by a lever, by which a telephone operator is enabled to connect his telephone with the line of any subscriber.

Lithanode.—Compressed peroxide of lead prepared for use as electrodes in storage batteries.

Litharge.—The yellow oxide of lead, also known as *lead monoxide* and *massicot*. A compound of lead and oxygen which when made into a paste with sulphuric acid or with a solution of magnesium sulphate is pressed into the holes of the negative plate of a storage battery, when the "pasting" process is employed in forming.

Lithium.—A silvery white metal, melting at 370° Fahr. It is the lightest solid known, its specific gravity being 0.59 or 36.7 pounds to a cubic foot. It resembles sodium and potassium, and is a widely distributed element, occurring in sea water, mineral springs, tobacco ash, etc.

Litmus Paper.—A paper prepared and sold by druggists, used for indicating certain impurities found in boiler feed water. Water turning blue litmus paper red, before boiling, contains an acid, and if the blue color can be restored by heating, the water contains carbonic acid.

Live.—A term expressing anything that is operating or effective; that which exerts force or does work as distinguished from that which is dead or idle. A live axle of a motor car revolves, driving the wheels; a dead axle remains stationary, the wheels revolving upon it.

Live Load.—One that is put on suddenly, or is accompanied with vibrations; as the force exerted by the connecting rod of an engine, or by a train crossing a railway bridge; *a varying load.*

Live Steam.—Steam issuing under pressure from a boiler, as distinguished from *exhaust steam.*

Live Wire.—A wire in actual use as a part of an electric circuit, especially one through which a strong current is passing.

Lead.—1. In general, the work sustained by a machine.

2. As applied to a dynamo, the output in watts.

3. The resistance offered to a motor by the machinery it drives apart from the friction of its own parts.

Load Curve of Station.—The characteristic curve tracing the electric output of a central station at every moment throughout the day.

Load Equalizing.—When a number of compound dynamos of different outputs, size, or make are running together in parallel, it frequently happens that all their characteristics are not exactly similar, and therefore the load is unequally distributed among them, some being overloaded, while others do not take up their proper share of the work. If the difference be small, it may be compensated by means of the hand regulator; if large, however, other means must be taken to cause the machines to take up their due proportion of the load. If the shunt coils of the several dynamos be provided with small adjustable resistances, in the form of German silver or copper ribbon inserted in series with the coils, the distribution of the current in the latter may be altered by varying the resistance attached to the individual coils, and thus the effect of the shunt coils upon the individual armatures in raising the pressure may be adjusted, and the load thus evenly divided among the machines.

Lead Factor.—The ratio of the average power of a machine, plant or system to the maximum power during a certain period of time, being usually expressed in the percentage which the average load is to the maximum.

Lead Panel.—In a system of electric distribution, a switchboard supplied with the devices for recording the electric output of the central station.

Load Rating.—In steam engineering, the process of estimating or ascertaining the amount of work done by an engine working up to its capacity. Not to be confounded with the calculation of *duty.*

Local Action of Dynamo.—Wasteful activity in the working parts of a dynamo due to eddy currents.

Local Action of Voltaic Cell.—Wasteful chemical action which goes on in a voltaic cell when the circuit is open, due to impurities in the zinc or to the varying density of the electrolyte. Such action may also occur when the circuit is closed without contributing to the useful current.

Local Battery.—In telegraphy, a battery for a local circuit, supplying the current for the station instruments.

Local Battery Circuit.—In telegraphy, the circuit operated by the local battery of a station.

Local Call.—A call received at a telephone exchange from a subscriber, as distinguished from a call coming through another exchange.

Local Currents.—1. Useless electric currents sometimes generated in an armature core producing injurious heat. This tendency is reduced by laminating and insulating the core. Local currents are also known as *eddy* currents or *Foucault* currents.

2. In a primary cell, chemical action that tends to eat away the zinc, owing to the impurities in the metal. It may be prevented by amalgamating the zinc.

Local Faradization. — In electro-therapeutics, the application of faradization to a limited part of the body.

Localization of Faults.—The act or process of locating a fault in a line or cable by making capacity tests.

Localization Test.—A capacity test applied to a line or cable in order to locate a fault.

Localized Capacity.—Capacity introduced into a circuit at special points in addition to that already existing in the circuit.

Localized Inductance.—Inductance introduced into a circuit at special points in addition to that already existing in a circuit.

Local Jack.—In a multiple telephone switchboard, the *answering* jack by means of which the operator responds to a signal received at the operator's section.

Locally Interconnected Switchboard.—A telephone switchboard arranged in sections which are connected with one another.

Location.—1. In surveying, staking out the boundaries of an area, determining points

through which a road or railway shall pass, or marking out with stakes sites decided upon for mining or boring operations.

2. Position, site.

3. Anything marked out; a measured area.

Lock, Electric.—An electrically operated spring lock released by a push button at some distance from it.

Lock Faucet.—A tap or faucet capable of being secured with lock and key.

Lock Gate.—A water tight door fitted with sluices and working upon hinges, used to close the entrance to a lock on a canal or dock. The water level is equalized either side of the gate to be opened by means of the sluices, the gate then being swung on its hinges to permit the passage of a craft.

Lock Nut.—A nut having an inwardly projecting pin or other means for holding it against a possibility of jarring loose.

Lock Out System.—A telephone system containing a lockout mechanism for securing secrecy in party lines, so that a subscriber may not intrude upon and overhear the conversation of other subscribers on the line, nor interrupt when the line is already busy.

Locomotive, Electric.—A car or engine carrying an electric motor for drawing trains, especially in electrified systems of interurban or trunk line railways. Electric motors vary greatly in form as no standard shape is yet established. In the smaller locomotives, the motor is usually geared to the driving axle by what is called single reduction; in the larger type the motor is directly connected without gearing.

Lodestone.—A variety of magnetite, or the magnetic oxide of iron, possessing in a natural state the properties of a magnet; a natural magnet. It was the first substance in which the phenomenon of magnetism was observed, and not until the tenth or twelfth century was it discovered that lodestones possessed the property of pointing north and south when hung up by a thread. This property was turned to advantage in navigation, and from that time the magnet received the name of *lodestone* or "leading stone." It is commonly, though incorrectly, spelled loadstone.

Log.—1. An abbreviation for *logarithm.*

2. A stick of timber butted on the ends; a piece of timber, trimmed of branches, etc., ready for the saw mill.

3. The engine room log kept by the chief engineer, giving a tabulated summary of the performances of the machinery, and the consumption of fuel, together with all repairs executed, etc.

Logarithm.—In higher mathematics, one of a class of artificial numbers, devised by Napier (A. D. 1600), to abridge arithmetical calculations, and by the use of carefully prepared "Tables of Logarithms," to shorten the difficult operations of *raising to powers* and *the extraction of roots.*

Logarithmic Curve.—A curve having ordinates increasing arithmetically, while its abscissas increase geometrically.

Logarithmic Decrement of Galvanometer.—The ratio of the amplitude of one swing of a galvanometer needle to the next following one.

Log, Electric.—An electric apparatus devised for measuring the speed and progress of vessels at sea.

Logging Motor, Electric.—A traveling motor for hauling logs, used in lumbering operations.

Long Arc Electric Lighting.—An arc light system in which unusually long arcs are maintained.

Long Closed Circuit.—A circuit in which all the related parts are connected, as distinguished from one having some of its receptive devices disconnected.

Long Coil Magnet.—An electromagnet wound with many turns of fine wire, for use on long circuits where there is high resistance.

Long Core Magnet.—An electromagnet furnished with a core of considerable length.

Long Distance Telephone.—A term sometimes applied to toll line systems for communicating to distant points. Special switchboards are provided for connecting local to distant subscribers, and specially constructed cables join the various stations.

Long Distance Telephone Cabinet.—A silence cabinet for use in long distance telephoning.

Long Distance Transmission.—The transmission of electric current for lighting, traction, power driving or other pur-

poses from a generating center to distant points at which the current is utilized. In long distance transmission, high tension alternating currents are used by both three phase three wire and two phase four wire systems, the former being preferred for greatest distances because of its economy of copper.

Long Distance Transmitter.—A telephone transmitter, such as the solid back transmitter, adapted for use on long distance lines.

Longitude.—In geography and navigation, the arc or distance east or west on the earth's surface intercepted between the meridian of a given place and the meridian of some other place from which longitude is reckoned, usually from Greenwich, England, but also, sometimes, from the capital of a country, as from Washington or Paris. The longitude of a place is expressed either in degrees or in time; as, that of New York is 74° or 4 h. 56 min. west of Greenwich.

Longitudinal.—Appertaining to length or to longitude; a longitudinal section is one taken parallel with the length or longest line of the object, as distinguished from a *transverse*, or one taken across.

Longitudinal Magnetization.—Magnetization of an iron bar such that the magnetic axis of each molecule coincides in direction with the length of the bar; a state of magnetic saturation.

Longitudinal Riveting.—The lengthwise seams in a boiler shell, which have to resist the bursting strain of the steam, and are, consequently, sometimes double or treble riveted with inside and outside butt or welt straps.

Longitudinal Vibrations.—Vibrations of an elastic medium parallel to the length of the medium.

Long Range Electrometer.—An electrometer capable of making measurements over an extended range.

Long Shunt Compound Winding.—A method of compound winding in which the shunt winding is connected around the series coil.

Long Shunt Compound Wound Dynamo.—A compound wound dynamo employing the long shunt arrangement of the shunt winding.

Long Shunt Winding.—In a compound wound dynamo or motor, a shunt winding connected across the terminals.

Loom, Electric.—A loom for Jacquard weaving in which metal plates are substituted for the perforated cards, and electromagnets are used for their operation.

Loop Bracket.—A bracket with one or more insulators at a point where a loop is introduced into a circuit; a spreader bracket.

Loop Break.—An insulating device for holding the ends of a conductor which has been cut for the introduction of a loop.

Loop Circuit.—1. A branched or parallel circuit.

2. A circuit not having a ground return; a metallic circuit.

Loop Cut Out.—A cut out included in an electric loop.

Loop, Electric.—A secondary circuit branching from the main line and returning to it.

Looping-in.—A term sometimes applied to the method of wiring a series telephone party line, in which the line circuit passes from one instrument to the next throughout the entire circuit.

Loop Mile.—A branching and returning conductor for a distance of one mile in a loop circuit.

Loops of Mutual Induction.—Lines of induction in an electrical circuit caused by the varying intensity of the current in an adjacent circuit.

Loop Switch.—A switch by means of which a loop is cut in or out of a main line.

Loop System of Distribution.—An early method of distribution in an electric lighting system in which each lamp obtained its currents through a separate circuit of its own.

Loop Test.—A method of locating a fault in a telegraph or telephone circuit when there is a good wire running parallel with the defective one. In the process the good and bad wires are joined at their distant ends and one terminal of the battery is connected to a Wheatstone bridge, while the other terminal is grounded.

Loop Winding.—A lap winding, in which the connections, instead of progressing in a "wave" around the core, are made between adjacent coils in series.

Loose Carbon Transmitter.—The granular carbon or dust telephone transmitter, in which a mass of carbon grains is held between flat carbon electrodes for varying the resistance of the circuit.

Loose Contact.—A contact in which two surfaces touch each other lightly.

Loss of Continuity.—An interruption or break in an electric circuit.

Loss of Head.—In hydraulics, the diminution in the weight and pressure of a liquid column. Loss of head is due to the friction of long pipes and to the presence of short bends.

Loss Plate of Voltameter.—The plate in a metal voltameter at the anode, and hence the one attacked by the acid of the solution and dissolved.

Lost Amperes.—In a shunt dynamo, that portion of the current which flows through the coils of the field magnets instead of through the external circuit. For machines of high efficiency the lost amperes are but a small fraction of the total current generated.

Lost Motion.—In mechanics, motion in part of a machine producing no useful result, either because of wear in the bearings or through imperfect mechanical construction.

Loudness.—The intensity of a sound, depending upon the energy of the vibrations transmitted to the ear.

Loud Speaking Telephone.—A telephone in which the conversation is heard in the receiver with unusual loudness.

Low Efficiency Lamp.—An incandescent lamp is said to burn with a low efficiency when it consumes more than 33 or 35 watts per candle hour.

Low Frequency.—A comparatively small number of complete cycles of vibration performed in a unit of time.

Low Frequency Transformer.—A transformer adapted to an alternating circuit of low frequency.

Lowmoor Iron.—A very good quality of iron made at Lowmoor in Yorkshire. Since the permeability of different qualities of iron varies greatly too great care cannot be exercised in its selection. Ewing has succeeded in forcing 45,350 lines of force per square centimeter through a sample of Lowmoor iron. To obtain this a magnetising force of H = 24,500 had to be employed.

The Yorkshire wrought irons are nearly pure, on account of the care taken in their manufacture, the iron being *refined* as well as *puddled*. An additional circumstance contributing to their high quality is the entire absence of sulphur from the fuel used in the operations. Lowmoor iron is specified wherever a piece has to stand much working in the fire, or wherever absolute soundness is a necessity.

Low Potential Current.—A current having a low electromotive force.

Low Potential System.—An electric system in which the pressure is under three hundred volts.

Low Pressure Circuit.—A circuit employing a current of low voltage.

Low Pressuro Cylinder.—The largest cylinder in a compound or triple expansion engine; the measure of power in an engine, to which all the pressures are referred for purposes of comparison.

Low Pressure Engine.—One which condenses its steam and discharges it as water in distinction from a *high pressure engine* or one run non condensing.

Low Pressure Incandescent Lamp.—An incandescent lamp adapted to a low pressure circuit, and having a short and thick filament of low resistance.

Low Resistance Magnet.—A magnet wound with short coils of thick wire, offering low resistance.

Low Speed Motor.—An electric motor intended for low speed running.

Low Tension.—Low electric pressure.

Low Tension Bus.—A bus bar designed for low voltages.

Low Tension Electric Fuse.—A fuse for exploding a charge by the aid of an electric current of low pressure.

Low Tension Insulator.—An insulator employed on low tension electric circuits. In overhead lines it is usually of glass or porcelain with one or more bells or petticoats to prevent leakage.

Low Tension Switch.—A switch designed for circuits of low electric pressure.

Low Vacuum.—An enclosed space from which the air or gas has been exhausted to an imperfect degree, so that a greater or less amount of residual gas remains.

Loxodograph.—An electrical instrument in which the joint action of magnetism and photography is utilized for recording the course of a vessel at sea.

Lubricate.—To make two surfaces act smoothly in contact with each other by the application of oil, or an oily substance, for the purpose of diminishing friction.

Lubricant on Commutator.—In most cases it will be found that a little lubricant is needed on the commutator in order to prevent cutting of the latter by the brushes, and this is especially the case when hard strip brushes are used. The quantity of oil so used should be very small, a few drops smeared upon a piece of clean rag, and applied to the commutator while running, being quite sufficient. It is advisable to use mineral oil, such as vaseline, or any other hydrocarbon. Animal or vegetable oils should be avoided, as they have a tendency to carbonize, and thus cause short circuiting of the commutator, with attendant sparking.

Lubricating Oil.—1. Any oil used for the purpose of diminishing friction.

2. Engine oil for lubricating external running parts, as distinguished from that used for internal lubrication.

3. A mineral lubricant obtained during the distillation of petroleum.

Lubrication.—1. In machinery, to cause to slip easily; to supply to moving parts and their bearings, grease, oil or other lubricant, for the purpose of lessening friction.

2. The theory of lubrication is the interposition of a film of unguent between the two surfaces which are supposed to rub together by reason of the motion of one of them. The friction of the surfaces on the unguent is less than their friction on one another, so that lubrication lessens friction, saves power and diminishes the risk of damage, wear and tear. For steam cylinders, air compressors, etc., a lubricant with a high flash point or temperature of decomposition, and great viscidity is needed, qualities found in mineral oils only; heavy bearings require an oil with great weight and body, so that it shall not be squeezed out by the pressure; small high speed parts require a thinner oil. These latter qualities are provided for by different compounds of animal and vegetable oils, with some mineral additions.

Lubricator.—A device used for holding oil or grease and supplying it in regular amounts to a journal or bearing. The supply is fed either by worsted syphons, by gauged drips, or by a needle which comes up from the shaft through the neck of the lubricator and induces feeding by capillary attraction and the shaking of the needle. Also called ***sight feed lubricator, grease cup***, etc.

Lullin's Experiment.—Two peculiar effects were observed by Lullin when a piece of cardboard is pierced by a spark: (*a*) a slight burr is raised on each side, as if the hole had been made from the interior outwards; (*b*) if the two electrodes are not exactly opposite each other, the hole is found to be nearer the negative point. When the experiment is tried in a vacuum, no such displacement of the hole occurs.

Lumber.—Timber hewed or sawed into convenient shapes for use. The term conveys the idea of wood dressed into large beams or joists near where it was felled.

Lumen Meter.—An instrument for measuring illumination.

Lumination.—An abbreviated form proposed as a substitute for the term illumination.

Luminescence.—The phenomenon, exhibited by certain bodies, of absorbing light waves and then emitting again a sufficient portion of them to be visible. Luminescence has two manifestations, *fluorescence and phosphorescence.*

Luminescence Lamp.—A term sometimes applied to an X-ray lamp.

Luminometer.—A name given to a form of photometer. It consists of a box with two tubes opening into it. One of the tubes admits the light while the observer looks through the other at a card of printed matter illuminated by the light to be measured. The distance at which the card can be read is that which determines the illuminating power of the lamp.

Luminosity.—1. The quality of being luminous or light giving.

2. As applied to color sensation, the brightness of the color.

Luminous Absorption.—The absorption of light rays by a body through which they are passing; as illustrated by the effect upon the intensity of an electric light by the globe of the lamp.

Luminous Arc Lamp.—A name sometimes given to a variety of arc lamp known as the

magnetite arc lamp. The lower electrode is composed of magnetite or a similar substance powdered and compressed into a sheet iron tube. The upper electrode is of copper which reduces very slowly. The light is given from the arc itself which is nearly 20 mm. (¾ in.) long. Also called *flaming arc lamp.*

Luminous Effects of Spark.—When a disruptive discharge takes place, the spark is usually a thin brilliant streak of light. If metallic balls be used as sparking electrodes the distance between the balls modifies the character of the spark, viz.: When the balls are close together the spark appears as a single thin and brilliant line. If the distance be increased, the spark takes an irregular zigzag form, following the path of least resistance. The presence of minute particles of dust or other matter floating in the air causes the zigzag path. The length of a spark depends upon the electrical and atmospheric pressures and the temperature of the air in which the discharge takes place. The brilliancy of the spark depends upon the quantity of current, and the color varies with the nature of the metal of the electrodes because the spark tears away minute particles of the metal and volatilizes them in its passage.

Luminous Efficiency.—The luminous radiation of a source of light in a given time considered in relation to the total radiant energy of that source in that time.

Luminous Flame.—That which burns with a bright yellow to white color. All flame under a boiler is not luminous, sometimes the whole or a part of it will be red or blue.

Luminous Flux.—A flux or flow of light waves.

Luminous Flux Unit.—A unit flux of light, being that flux sent by a source of unit intensity through a unit solid angle; the *lumen* or *candle lumen.*

Luminous Frequencies.—In waves of radiant energy, frequencies sufficient to produce light.

Luminous Intensity.—The ratio between the quantity of light radiated and the surface area of a luminous source.

Luminous Interference.—The interference of light waves differing in phase, so that the light undergoes a change, or is extinguished.

Luminous Pane.—An insulated square of glass having a narrow strip of tin foil fastened upon it in parallel or zigzag rows, on which spaces are cut to represent any desired pattern; when an electric discharge is passed through the foil the design becomes reproduced in luminous flashes.

Luminous Radiation.—Radiation capable of producing the sensation of light.

Luminous Radiator.—A portable heating device consisting of a metal frame with polished copper reflector containing from two to four luminous heating units. These units are similar to incandescent lamps, being cylindrical chambers of frosted glass containing a filament which emits heat upon the passage of the current.

Lummer Brodhun Photometer.—A form of photometer including an optical train mounted in a sight box, and provided with an optical device for viewing both sides of the screen at once.

Lunar Inequality.—Slight variations of the magnetic declination and inclination of a magnetic needle due to the effect of the moon upon the earth's magnetism.

Lutes.—These are soft adhesive mixtures, principally earthy, used for closing apertures existing at the junction of different pieces of apparatus used for melting; the material used for rendering air tight those vessels which have to be exposed to the heat of a melting furnace; as, *crucibles, annealing pots,* etc.

Lux.—A unit of photometric measurement. It is the intensity of illumination produced by a *lumen* at one meter distance from the source of light; plural, *luces.*

M—The symbol for the magnetic moment of a magnet.

m.—1. Abbreviation for mass.
2. The symbol for unit quantity of magnetism, or unit pole.
3. Abbreviation for meter, a unit of length.
4. Abbreviation for minute, a unit of time.

μ—The Greek letter (*mu*) corresponding to *m*, used: (1) as the symbol for magnetic permeability, (2) as the symbol for micron, a unit of length.

$\mu\mu$—The double Greek letter (*mu*) corresponding to *m*, used as the symbol for bicron, a unit of length.

m. a.—Abbreviation for milli-ampere.

Maceration.—The process of softening a substance by soaking it in a fluid, usually without heat.

Machine.—This word is most commonly applied to such pieces of mechanism as are used in the industrial arts for mechanically shaping, dressing, and combining materials for various purposes; machines are frequently named from their use, as, screw cutting machines, or from the thing made or acted upon; as, machine ruler; *compound* machines are formed from two or more *simple machines*. *Tools* are the simplest implements of art; these when they become complicated in their structure become machines, and machines when they act with great power are usually termed *engines*.

Machine Bolt.—A bolt screwed at one end, with a head on the other, used to secure two pieces together, passing through clearance holes in both, and fastened with a nut on the far side. The head of a machine bolt is generally square or hexagon, although round, snap, countersunk, or other heads are used for special purposes.

Machine Screw.—A fine threaded screw used to connect parts of machinery together, having a bolt thread such as the V or U. S. standard, as distinguished from a *wood screw*. The machine screw usually passes through a clearance hole in one piece to secure it to another which has a threaded hole.

Machine screws find considerable use in the construction of electrical apparatus. Some of the standard sizes are as follows:

Standard Machine Screws.

No.	Threads per Inch.	Diam. Body.	Lengths.	
			From	To
4	32, 36, 40	.1105	3-16	¾
6	30, 32	.1368	3-16	1
8	30, 32	.1631	¼	1¼
10	24, 30, 32	.1894	¼	1½
12	20, 24	.2158	⅜	1¾
14	20, 24	.2421	⅜	2

Machine Seal.—A method of sealing air tight the bulb of an incandescent lamp in the process of manufacture.

Machine Telegraphic Transmission.—Automatic telegraphic transmission.

Machine Telegraphy.—Automatic telegraphy.

Machine Tool, Electric.—A machine tool operated by electricity.

Made Circuit.—A closed or completed circuit.

Magazine Fuse.—A safety fuse provided with duplicate fuses in reserve, so that when one becomes burned out, a new fuse may readily be substituted.

Magnalium.—An alloy of aluminum and magnesium with 90-98% aluminum. It is used largely in Europe for engine parts, scientific instruments, telephone and telegraph apparatus, etc. It has greater strength and lower unit weight than pure aluminum, and its electric and heat conductivity is 56% of pure copper.

Magne-crystallic Action.—A name given by Faraday to the behavior of

crystalline bodies under the influence of magnetic force, such that the magnetism varies according to the axes of crystallisation. He found, in experimenting with a crystal of bismuth, that it tended to point with its axis of crystallisation along the lines of the field axially.

Plücker endeavored to connect the magne-crystallic action of crystals with their optical behavior. In bodies, which like slate, have cleavage, the planes of cleavage are usually at right angles to the magne-crystallic axis.

Magne-crystallic Force.—A name given by Faraday to the magnetic force acting upon crystals according to the character of their structure.

Magne-electric Induction.—A variety of induction producing electric currents by the movement past each other of a conductor and a permanent magnet.

Magnesia.—The oxide of magnesium. A light white powder with a slight alkaline reaction. It is nearly insoluble in water and melts *only at the temperature of the electric furnace.* It is therefore used for crucibles and furnaces for high temperature processes.

Magnet.—A body possessing the property of attracting to itself particles of iron. A natural magnet is a piece of magnetite or magnetic oxide of iron which will attract other iron, will repel or attract similar magnets according to their relative positions, and when suspended so as to be free to turn will set itself in a definite direction with respect to the earth's magnetic poles. An artificial magnet is a piece of iron or steel which has acquired magnetic properties. An electromagnet is a piece of iron which has been magnetised by an electric current passing through a wire coiled about the iron. A polarized electromagnet is one whose core is a permanent magnet. Such magnets are used in duplex telegraphy. The armature of this magnet is released only by a current in a fixed direction.

Magnet Coil.—A conducting coil of insulated wire wound around the core of an electromagnet; a *solenoid.*

Magnet Core.—The bar of iron or steel about which a magnet coil is wound to form an electromagnet.

Magnetic.—Relating to a magnet, or magnetism.

Magnetic Adherence.—The tendency of iron to cling to a magnet; and of unlike poles of two magnets in contact to adhere to each other.

Magnetic Ælotropy.—The quality of a mass of iron by which it shows different susceptibilities to magnetism in different directions.

Magnetic Air Circuit.—A magnetic circuit completed across an air gap.

Magnetic Attraction.—The attraction exerted by opposite magnetic poles upon each other.

Magnetic Austral Fluid.—The imaginary fluid formerly supposed to exist at the south pole of a magnet.

Magnetic Axis.—A line joining the two poles of a magnet or magnetic needle.

Magnetic Battery.—A magnet made up of a number of magnets joined by their similar poles; *a compound magnet.*

Magnetic Bearing.—The angle formed by a line drawn to an object from the eye of an observer, and the line of the magnetic meridian in which the observer stands.

Magnetic Bearing Compass.—An instrument for observing the magnetic bearing of a place.

Magnetic Belting.—A type of machinery belting having iron strips inserted at intervals in its length, so that, in passing over a magnetized pulley, the grip on the pulley is strengthened.

Magnetic Blow Out.—1. A device by means of which an arc accidentally arising in the parts of an electrical instrument may be extinguished by the action of an electromagnet.

2. A strong electromagnet provided in the controller of an electric car to blow out the arcs and sparks arising from the frequent disconnections made with the controller, thereby preventing the destruction of the contacts and brushes.

Magnetic Blow Out Lightning Arrester.—A form of lightning arrester employing an electromagnet for extinguishing the arc of the discharge.

Magnetic Boreal Fluid.—The imaginary fluid formerly supposed to exist at the north pole of a magnet.

Magnetic Bridge.—An instrument for measuring the resistance offered by an iron core to the passage of magnetism.

Magnetic Cage.—Magnetic force does not act across a screen of iron or other magnetic material if sufficiently thick. Hence, if a magnet be placed inside a hollow iron ball, no outside magnet will affect it on account of the magnetic lines of force being conducted off through the iron sphere instead of penetrating it. A shell of iron will isolate the inside space from external magnetic influences and is therefore called a *magnetic cage.*

Magnetic Chart.—A map upon which lines are drawn connecting different points upon the earth's surface having the same magnetic conditions. These lines may be *isogonic* lines connecting places which have the same declination, or *isoclinic* lines joining points of the same inclination or dip.

Magnetic Circuit.—The path of magnetic flux in a magnetic substance or in electric or magnetic apparatus. The greater part of such a circuit is usually in magnetic material, but there are often one or more air gaps included. The magneto-motive force may be supplied by coils of wire carrying electric current or by permanent steel magnets.

The law of the magnetic circuit is as follows:

$$N = \frac{M}{Z}$$

in which, N is the magnetic flux, M, the magnetomotive force and Z, the reluctance.

Magnetic Circuit Breaker.—A device for opening a circuit by the action of an electromagnet.

Magnetic Circuit Closer.—A device for closing a circuit by the action of an electromagnet.

Magnetic Closed Circuit.—A magnetic circuit composed of iron throughout.

Magnetic Clutch.—A clutch operated by an electromagnet for obtaining a grip upon any moving part of an apparatus.

Magnetic Coercive Force.—The reverse magnetizing force necessary to completely remove the residual magnetism from a substance that has been magnetized. The better the quality of the iron the less the remaining magnetism and hence the less coercive force required.

Magnetic Compensator.—A magnetic device for overcoming the influence of local attraction upon the needle of a ship's compass.

Magnetic Concentration.—A process of separating the iron from the gangue, or foreign matter in iron ore, by the use of a powerful electromagnet in a machine called an electromagnetic separator.

Magnetic Conduction Current.—The rate of flow of magnetism through a magnetized body.

Magnetic Connection.—A connection existing between two magnetic circuits when there is an intermingling of magnetic flux.

Magnetic Control of Galvanometer Needle.—The adjustment of the directive tendency of a galvanometer needle by the use of a controlling or compensating magnet.

Magnetic Couple.—A pair of equal and opposite forces which act upon a magnetic needle so as to bring it into the earth's magnetic meridian.

Magnetic Creeping.—A gradual increase in magnetism which proceeds in a body under constant magnetizing force; viscous hysteresis; sometimes called *time hysteresis.*

Magnetic Cross Flux.—A magnetic flux in a transformer opposing the usual flux, and causing magnetic loss.

Magnetic Current.—A term used to express the flow of magnetism along the surface of a magnetized body.

Magnetic Curves.—Curved lines representing the direction of the magnetic force, shown by the self arrangement of iron filings when sprinkled upon a piece of paper or glass which is gently jarred by tapping while held in a magnetic field; magnetic figures.

Magnetic Curve Tracer.—An instrument for tracing the characteristic curve representing the varying magnetic intensity of a mass of iron under varying alternations of the magnetizing current.

Magnetic Declination.—The angle between the magnetic meridian of a place upon the earth's surface as indicated by the compass needle, and the geographic meridian of that place. This difference is due to the fact that the magnetic pole to which the needle points does not coincide with the earth's geographic north pole.

Magnetic Deep Sea Thermometer.—A thermometer for ascertaining deep water

temperatures, employing a magnet for resetting the registering markers.

Magnetic Density.—The number of lines of magnetic force passing through a magnet or magnetic field per unit area of cross section.

Magnetic Detector.—In wireless telegraphy, a variety of receiving instrument for detecting the arrival of electromagnetic waves, based upon the principle that rapidly alternating currents permanently modify the magnetization of a magnetized steel bar.

Magnetic Deviation.—Variation of the magnetic needle due to special local conditions other than the true magnetic variation of the place, shown when iron is present in the vicinity of the needle, especially on shipboard.

Magnetic Diffusion.—A leakage of magnetic flux that often takes place along paths that stray from the main magnetic circuit and are lost. Some of this leakage takes place through the air, and it is this that affects watch springs in the neighborhood of electric generators.

Magnetic Dip.—The same as magnetic *inclination.*

Magnetic Discontinuity.—A break in the continuity of a magnetic circuit.

Magnetic Dissymmetry.—The condition of a magnetic circuit in which the magnetic flux is not uniform.

Magnetic Disturbance.—Slight irregular variations of the magnetic needle, such as the disturbance due to a "magnetic storm."

Magnetic Divining Rod.—A name given to a dipping needle used to reveal the presence of iron ore in the ground.

Magnetic Effluvium.—A name given by the earliest investigators of magnetic properties to the phenomenon now known as magnetic flux, or *lines of force.*

Magnetic Elements.—The characteristics of the terrestrial magnetism at any point on the earth's surface, as shown by the effect on the magnetic needle: they are, (1) intensity, (2) declination or variation, (3) inclination or dip.

Magnetic Equalizer.—An arrangement by which the force of an electromagnet which varies in intensity through its range of operation in any mechanism, may be made uniform throughout.

Magnetic Equator.—1. A line joining all the places on the earth's surface where there is no inclination or dip, that is, where the magnetic needle is quite horizontal; a line midway between the magnetic poles; *the aclinic line.*

2. The section of a magnet half-way between its poles.

Magnetic Explorer.—An exploring coil connected with a galvanometer for the purpose of investigating an electromagnetic circuit in order to detect magnetic leakage, etc.

Magnetic Fatigue.—A term applied to the waste of magnetic power in iron by hysteresis after repeated cycles of magnetization.

Magnetic Fatigue of Transformer Core.—A waste of power by hysteresis in the iron core of an alternating current transformer due to repeated cycles of magnetization; aging of a transformer core.

Magnetic Field.—The region, surrounding a magnet, through which magnetic forces act; the space around the magnet in which the compass needle or other detector of magnetism will be affected. The magnetic field is said to be comprised of lines of force. It is most intense near the poles of the magnet and as the distance from the magnet is increased, these lines of force become weaker and weaker, until they finally disappear.

Magnetic Figures.—A term used to denote magnetic curves.

Magnetic Filament.—One of the chains or threads of polarized magnetic molecules conceived to exist in a magnetized substance.

Magnetic Flow.—A term sometimes used for magnetic flux.

Magnetic Fluids.—The imaginary fluids, supposed, in the early history of the study of magnetism, to account for the various magnetic phenomena.

Magnetic Flux.—The average field intensity of a magnet multiplied by its area; its unit is the *maxwell.*

Magnetic Flux Density or Intensity.—The total lines of magnetic force passing through a magnet or magnetic field per unit area of cross section; *magnetic density.*

Magnetic Flux Paths.—Paths followed by magnetic flux.

Magnetic Foci.—Points on the earth's surface, in the vicinity of the magnetic poles, where the earth's magnetic force is greatest.

Magnetic Force.—The force by which attraction and repulsion is exerted by the poles of a magnet.

Magnetic Friction.—A term sometimes applied to *hysteresis.*

Magnetic Gearing.—Friction gear in which wheels are drawn together by magnetic adherence.

Magnetic Generator.—A term sometimes applied to a magneto, a machine for generating electricity by use of permanent magnets instead of electromagnets; a *magneto-generator.*

Magnetic Helix.—A solenoid, or conducting coil of insulated wire wound around the core of an electromagnet; a *magnetic coil.*

Magnetic Hysteresis.—The tendency of a magnetic substance to persist in any magnetic state that it may have acquired. It is a kind of friction between the molecules of iron which causes magnetism to lag behind the magnetizing force.

Magnetic Impermeability.—The resistance offered by a magnetic circuit to the flow of magnetism; *magnetic reluctance.*

Magnetic Inclination.—The inclination or dip of the magnetic needle. The angle which the needle makes with the horizontal when it is free to move in a vertical plane. The inclination varies at different parts of the earth's surface and also changes from year to year. At the north magnetic pole the needle would dip straight down.

Magnetic Induction.—The communication of magnetism to iron by the mere presence of a magnet without actual contact, an action similar to electrostatic induction. If a short thin unmagnetized bar of iron be placed near some iron filings, and a magnet be brought near the bar, magnetism will be induced in the bar by the presence of the magnet. It will be found that the iron bar thus magnetized has two poles; the pole nearest the pole of the magnet being of the opposite kind and the pole at the further end of the bar being of the same kind.

Magnetic Inductive Capacity.—A term sometimes applied to *permeability* which is the ratio between the number of lines of magnetic force per unit area running through a magnetizable substance and the magnetizing force applied to the substance.

Magnetic Inertia.—The quality of a magnetic substance which causes it to acquire and part with magnetism slowly.

Magnetic Intensity.—The amount of the earth's magnetic force at any place; in the northern hemisphere it is the resultant of two component forces at right angles to each other, one acting in a vertical direction tending to depress the north seeking pole of a magnetic needle, and the other acting in a horizontal direction compelling the needle to point to the magnetic north.

Magnetic Iron Ore.—A native oxide of iron, possessing the property of attracting iron fragments. When crystallized it is known as *lodestone.* The ore is found largely in Arkansas, Spain, Sweden and other parts of the world, though not always in the magnetic condition. It sometimes occurs in crystals having an octahedron form. Magnetic oxide of iron is also called *magnetite.*

Magnetic Joint.—A joint uniting two portions of a magnetic circuit.

Magnetic Lag.—The tendency of induced magnetism in iron and steel to lag behind the magnetizing force which produces it; also called magnetic *inertia* and magnetic *viscosity.*

Magnetic Lag Motor.—A motor that derives its torque from magnetic lag.

Magnetic Latitude.—Latitude on the earth's surface considered with reference to the magnetic equator.

Magnetic Leakage.—In a dynamo, stray lines of magnetic force which leak around the armature instead of passing through it.

Magnetic Leakage Factor.—In a dynamo, the ratio of the total magnetic flux

generated to the useful flux entering the armature.

Magnetic Lightning Arrester.—A magnetic blowout lightning arrester.

Magnetic Limbs.—The parts of a magnet core; the legs of an electromagnet.

Magnetic Limit.—The highest temperature to which a magnetized substance can be heated without losing its magnetism.

Magnetic Line Protector.—A device including an electromagnet for protecting electrical apparatus connected with an overhead line from injury by lightning.

Magnetic Lines of Force.—Certain lines or directions in which magnetic induction takes place through a magnetic substance.

Magnetic Maps.—Charts on which all places having the same declination are joined by a line called an *isogonic line*; the line passing through places of no declination is called an *agonic* line.

Magnetic Mass.—A term applied to the quantity of magnetism residing at the pole of a magnet.

Magnetic Meridian.—A great circle assumed to pass over the earth's surface through the magnetic axis determined by a magnetic needle at rest.

Magnetic Metals.—The following metals in addition to iron are recognized as magnetic: *nickel, cobalt, chromium* and *cerium.* With respect to magnetic properties, only cobalt and nickel are comparable with iron, in fact they all are inferior.

Magnetic Metal Separator.—1. A machine employed in sorting out iron particles from brass turnings and filings by means of magnetic attraction. The turnings are fed into the machine and pass between rolls armed with magnets, and iron or steel fragments adhering to the latter are swept off into receptacles by brushes, against which the magnets revolve, while the brass falls straight through.

2. A similar device which has been employed to separate iron from finely pulverized ore.

Magnetic Molecule.—A *molecular magnet,* that is, a molecule of a piece of magnetized iron or steel considered as a diminutive magnet.

Magnetic Moment.—As applied to a uniform bar magnet, the product of the strength of one of its poles by the distance between the poles.

Magnetic Needle.—A small slender steel magnet mounted on a pivot or suspended by a thread, so as to be free to move in one or more planes. It naturally takes a position pointing north and south in the direction of the earth's magnetic poles.

Magnetic North.—The direction indicated by the north pole of a magnetic needle when free to turn upon its axis.

Magnetic Observatory.—A place for observing and recording variations of the earth's magnetism.

Magnetic Oscillations.—Oscillations performed by a magnetic needle after deflection before coming to a state of rest.

Magnetic Output.—In a magnetic circuit, the product of the magnetizing force by the magnetic flux.

Magnetic Paradox.—A peculiar effect produced by placing the north pole of a strong magnet at some distance from the north pole of a weak magnet. The north pole of the weak magnet will be repelled, but will be attracted when the strong magnet is brought quite near. The reason for this is that the magnetism induced in the weak magnet will be of the opposite kind and the pole of the magnet will be attracted. When the strong magnet is quite close to the weak one, the induced magnetism may overpower and mask the original magnetism of the weak magnet.

Magnetic Parallels.—A term sometimes applied to the *isoclinic lines,* the lines drawn upon a map joining places which have the same magnetic inclination or dip.

Magnetic Permeability.—The relative ease with which a body conducts lines of magnetic force; the ratio between the magnetizing force and the magnetic induction; the coefficient of magnetic induction. Permeability is the conductivity for magnetic lines of force. In other words, it is a measure of the ease with which magnetism passes through any substance. The permeability of good soft wrought iron is sometimes 3000 times that of air, varying with the quality of the iron.

The magnetic permeability decreases as the magnetisation increases. When a piece of iron has been magnetized up to a certain intensity its substance shows a tendency to reach magnetic saturation. In good iron this is reached at about 125,000 lines of force to the square inch of area of cross section.

Magnetic Permeance.—A measure of the flux which will be produced in a magnetic circuit by a given magneto-motive force. It is the reciprocal of reluctance. A circuit with unit permeance will require unit m. m. f. to produce unit flux.

Magnetic Permeation.—The passing of lines of magnetic force through a body.

Magnetic Perturbations.—Unusual disturbances in the earth's magnetism.

Magnetic Plug.—In an automobile motor, a make and break spark plug in which the terminals are separated by the action of a magnet within the plug.

Magnetic Points of Convergence.—Points on the earth's surface connected by the isogonic lines.

Magnetic Polar Area.—The portions of a magnet at or near the poles through which magnetic forces act.

Magnetic Polar Intensity.—The strength of the magnetic flux at the poles of a magnet.

Magnetic Polarity.—That property of a magnet in virtue of which it invariably possesses two poles.

Magnetic Polarization.—A condition attributed to the molecules of a magnetic substance to account for the nature of magnetism.

Magnetic Polar Surface.—The parts of a magnet at or near its poles.

Magnetic Poles.—1. The ends of a magnet, where the attractive force is greatest. In a bar magnet that end which tends to point north is called the north or positive pole, and the other the south or negative pole.

2. Those points on the earth's surface, in the neighborhood of the geographic poles, where the dipping needle would stand vertical.

3. A *unit magnetic pole* is one of such a strength that, when at a distance of one centimeter from a similar pole of equal strength, it will repel it with a force of one dyne. The relation between magnetic poles may be expressed by the equation:

$$f = \frac{m \times m^1}{d^2}$$

in which f is the force in dynes, m and m^1 the strengths of the two poles, and d^2 the distance between them in centimeters.

Magnetic Potential.—A conception applied to magnetism similar to electrical potential in electricity; the work which must be done to bring a unit north seeking pole from an infinite distance up to a given point.

Magnetic Pressure.—A force, analogous to electric pressure, which produces magnetic flux; *magneto-motive force.*

Magnetic Proof Piece.—A bar of iron employed for testing the strength and distribution of magnetism in a magnet.

Magnetic Proof Plane.—A small exploring coil joined in circuit with a sensitive galvanometer for the purpose of indicating the number and direction of the lines of force in a magnetic field.

Magnetic Reactance.—Reactance occurring in an electromagnetic coil.

Magnetic Reluctance.—The resistance against the passage of magnetic lines of force offered by the mass of a material. It is proportional to the length of the material, and inversely proportional to the area of the cross section and the permeability.

Magnetic Reluctivity.—Specific magnetic resistance or reluctance; the magnetic resistance offered by a unit cube of a medium; being the reciprocal of magnetic permeability.

Magnetic Remanence.—The power in a substance which resists magnetization and demagnetization, such that when the magnetizing influence is withdrawn the substance will retain a certain amount of *residual* magnetism; *magnetic retentivity.*

Magnetic Repulsion.—The repulsion exerted by like magnetic poles against each other.

Magnetic Resistance.—A term used to designate magnetic reluctance. It is the opposition which a medium offers to the passage of magnetic lines of force through it, i. e., the conductibility of magnetic lines of force. It is the reciprocal of magnetic permeability.

Magnetic Resistivity.—The specific resistance of a substance to magnetism, considered as the resistance of a centimeter cube of that substance.

Magnetic Retardation.—A retardation in the process of magnetizing shown by iron and steel; *magnetic inertia or lag.*

Magnetic Retentiveness, or Retentivity.—The same as magnetic remanence.

Magnetic Ringer.—An electromagnetic call bell.

Magnetics.—A name sometimes given to that branch of physics which treats of *magnetism.*

Magnetic Saturation.—The state of a magnet which has reached the highest degree of magnetization to which it can attain. A magnet, just after being magnetized, will appear to have a higher degree of magnetism than it is able to retain permanently: that is, it will appear to be supersaturated, since it will support a greater weight immediately after being magnetized than it will do after its armature has been once removed.

Magnetic Screen.—A hollow box or case of soft iron surrounding a body for the purpose of protecting it from the influence of an external magnetic field, used for example, to prevent a watch from becoming magnetized, or for protecting the needle of a marine galvanometer from the influence of the earth's magnetism; *a magnetic shield.*

Magnetic Screening.—Surrounding a body by a thick shield or screen of iron in order to protect it from the influence of an external magnetic field.

Magnetic Self-induction.—The tendency of a magnet to weaken its magnetism by inducing opposite polarity in its molecules.

Magnetic Sense.—A supposed special sense by which the influences of magnetism are perceived.

Magnetic Separator.—A machine consisting of a magnetized iron cylinder or drum, for separating magnetic substances like iron ore or iron filings and chips from mixtures, by causing them to adhere while the waste particles fall away.

Magnetic Shells.—The thin sheets in lamellar distribution of magnetism, made up of magnetic particles so arranged that one face of each layer contains *north seeking* magnetism and the other face *south seeking* magnetism; also called *lamellarly magnetized magnets.*

Magnetic Shunt.—In a magnetic circuit, a path through which a part of the lines of force are diverted in order to weaken the field, or to establish a shunt circuit.

Magnetic Shunt Circuit.—A branch magnetic circuit which diverts a portion of the flux of the main circuit.

Magnetic Solenoid.—A spiral made up of a narrow filament or wire magnetized throughout in the direction of its length.

Magnetic Sound.—A faint metallic sound sometimes heard when a bar of iron is suddenly magnetized or demagnetized; the magnetic tick or *Page effect.*

Magnetic Source.—Any source from which magnetic flux proceeds.

Magnetic Sticking.—A tendency which the armature of an electromagnet sometimes has of adhering to the poles after the current has ceased to flow in the coils.

Magnetic Storms.—Irregular disturbances of terrestrial magnetism simultaneously affecting the magnetic needle in various portions of the globe, supposed to be caused by great disturbances in the solar system; they frequently occur when the aurora is visible.

Magnetic Strain.—The effect upon any substance produced by the action of magnetic lines of force.

Magnetic Stream Lines.—The lines of magnetic force, being the paths followed by magnetic induction through a magnetic substance.

Magnetic Stress.—The influence of lines of magnetic force upon a substance exposed to their action, whereby a strain is produced in that substance.

Magnetic Substance.—Gilbert makes a distinction between magnets and magnetic substances. A lump of iron has no distinguishable fixed poles and no magnetic equator; it will attract either pole of a magnet no matter what part of the lump be presented to the magnet. This, according to Gilbert, is a *magnetic substance* as distinguished from a *true magnet* which has *poles.*

Magnetic Susceptibility.—The ratio between the intensity of the magnetization of a substance and the magnetizing force

applied to it to produce magnetization; the coefficient of magnetization.

Expressed as a formula:

$$k = \frac{I}{H}$$

in which k = susceptibility, I = intensity of magnetisation, and H = magnetising force.

Magnetic Theodolite.—An instrument for measuring the angle of declination of the magnetic needle.

Magnetic Tick.—A faint metallic sound which may be detected when a bar of iron is suddenly magnetized or demagnetized, called, from its discoverer, the *Page effect.*

Magnetic Time Constant.—A quantity used to express the time required for the current in an electric circuit to arrive at 63.2% of its full value when a constant E. M. F. has been impressed upon the circuit. The current theoretically requires an infinite time to reach its full strength as the impressed E. M. F. is opposed by a counter E. M. F. due to inductance.

Magnetic Traction.—The pull or lifting power of an electromagnet when its poles are in contact with its armature or keeper; the *tractive force.*

Magnetic Unit Pole.—A theoretical magnet pole assumed to repel another similar unit pole with a force of one *dyne* at a distance of one centimeter.

Magnetic Units.—A system of units in terms of which magnetic quantities and phenomena may be expressed. The magnetic units are derived from the fundamental units of *length*, *mass* and *time*, and are concerned with the force exerted between two magnetic poles. A few of them have been given specific names; as, *gauss*, the unit of magnetic field intensity; the *maxwell*, the unit of magnetic flux; and the *oersted*, the unit of reluctance.

Magnetic Vane Ammeter.—An ammeter in which two discs or vanes of soft iron, one fixed and the other free to move, repel each other; the swing of the movable vane indicating the strength of the current.

Magnetic Vane Voltmeter.—A voltmeter in which two discs or vanes of soft iron, one fixed and the other free to move, repel each other; the swing of the movable vane indicating the potential difference.

Magnetic Variations.—The elements of the earth's magnetism are subject to variations which occur in some cases every day, in others every year, and in still others at long intervals, sometimes extending over centuries. The changes that take place daily are known as *diurnal* variations, those that are observed yearly are called *annual* variations, while the changes that require many years are called *secular* variations.

Magnetic Variation Transit.—An instrument for measuring the angle of the magnetic declination.

Magnetic Variometer.—An instrument for measuring the variations in the magnetic forces of the earth's magnetism.

Magnetic Viscosity.—A tendency to retardation shown by induced magnetism in iron or steel; magnetic *lag.*

Magnetic Voltmeter.—A form of voltmeter employing a powerful U shaped permanent magnet and a moving coil.

Magnetic Whirls.—If a wire be moved near a magnet across a space in which there are magnet lines, the motion of the wire, as it cuts across those magnetic lines, sets up magnetic whirls round the moving wire.

The moving conductor so cuts the magnetic lines as to alter the number of lines of force that pass through the circuit. If a conducting circuit, as a wire ring or single coil, be moved along in a uniform magnetic field, so that only the same lines of force pass through it, no current will be generated. However, if a coil be tilted in its motion across the uniform field, or rotated round any axis in its own plane, the number of lines of force that traverse it will be altered, and currents will be generated. These currents will flow round the ring coil in the right handed direction (as viewed by a person looking along the magnetic field in the direction in which the magnetic lines run) if the effect of the movement is to diminish the number of lines of force that cross the coil; they will flow round in the opposite sense, if the effect of the movement is to increase the number of intercepted lines of force. If the field of force be not a uniform one, then the effect of taking the coil by a simple motion of translation from a place where the lines of force are dense to a place where they are less dense, will be to generate currents.

Magnetic Writing.—A variety of magnetic figures produced by writing with the pole of a magnet upon a thin sheet of steel and sprinkling iron filings upon it. The writing is reproduced by the lines of filings clinging to the magnetized parts.

Magnetine.—A name formerly given to the imaginary fluid in which magnetic phenomena were supposed to occur.

Magneting.—The process of passing the *slip*, in earthenware manufacture, through

a machine, furnished with revolving magnets which remove any particles of iron in the material.

Magnetism.—1. The peculiar property possessed by certain substances, especially iron or steel, in virtue of which they exert forces of attraction or repulsion according to fixed laws.

2. That branch of science which treats of magnets and magnetic phenomena.

The theory proposed to account for the magnetization of iron is as follows: Each molecule of iron is supposed to be, and to remain always, magnetic. In an unmagnetised iron bar these molecular magnets are arranged irregularly; the molecules resist being turned out of their usual positions. Hence when a magnetising force is brought to bear upon them, the first effect is to turn the molecules round, whose axes are already most nearly in the direction of the magnetising field.

As the magnetising force increases others are turned, increasing thereby the apparent magnetism; at last, all are turned with their poles in the direction of the magnetising field.

When this is the case, no further application of magnetizing force, however great, can increase magnetization. This is the point of saturation. On removing the magnetizing force, those molecules which have not been much strained out of their position, fall back to their old directions; but those which have been greatly strained have acquired a permanent *magnetic set*, and hence remain permanently magnetic.

Magnetism of Rotation.—A theory founded on the experiment of Arago's disc, that there exists a sort of magnetism in rotating bodies.

Magnetite.—The magnetic oxide of iron. A mineral which is attracted by a magnet, and sometimes acts as a magnet and attracts iron; *lodestone.*

Magnetite Arc Lamp.—A form of arc lamp containing a positive electrode of pure copper and a negative electrode consisting of a steel tube packed with a fine powder composed of oxide of iron (magnetite) and the oxides of chromium, titanium, etc. This lamp is operated on the direct current, and because of its fumes and sooty deposit is limited to outdoor lighting. It has high efficiency with a low maintenance cost, and gives a well diffused white light resembling sunlight.

Magnetizable.—Capable of becoming magnetized.

Magnetization.—The act of communicating or of acquiring magnetism.

Magnetization by Double Touch.—A method of magnetizing a bar or needle in which two bar magnets with their opposite poles together, slightly separated by an interposed piece of wood, are placed upon the middle of the bar to be magnetized, and then drawn back and forth several times along the bar, leaving off at the middle starting point.

Magnetization by Separate Touch.—A method of magnetizing a bar or needle by the use of two bar magnets placed with their opposite poles together at the middle of the bar, and then drawn apart simultaneously several times from the middle to the ends.

Magnetization by Single Touch.—A method of magnetizing a bar or needle by simply stroking each surface from end to end in one direction with the pole of a permanent magnet.

Magnetization Curves.—Characteristic curves tracing the relation of the magnetizing force to the resulting magnetic intensity. Magnetization curves are constructed by laying off the various values of the magnetizing force as abscissas, and the corresponding values of the magnetic intensity as ordinates.

Magnetize.—1. To communicate magnetism to a substance.

2. To become magnetic.

Magnetizee.—A person under the influence of mesmerism, or animal magnetism.

Magnetizer.—1. That which imparts magnetism.

2. A mesmerizer.

Magnetizing Ampere Turns.—The ampere turns of an electromagnet coil.

Magnetizing Coil.—A coil of insulated wire cemented together by shellac, carpenter's glue or gum copal, for the purpose of making magnets. The bar of iron is magnetized by passing it through the opening in the center of the coil while an electric current is passing through the turns.

Magnetizing Current of Transformer.—The current which enters the primary of a transformer when its secondary is on open circuit; the *open circuit,* or *leakage current.*

Magnetizing Currents.—Electric currents which, by passing through a coil of wire wound around a core of iron, produce

a strong degree of magnetization in the iron, thereby creating an electromagnet.

Magnetizing Flux.—Magnetic flux imparted to a substance in order to magnetize it.

Magnetizing Force.—The magnetic intensity impressed upon a substance in order to magnetize it.

Magnetizing Helix or Spiral.—A coil of insulated wire wound about the core of an electromagnet and serving to produce magnetization when an electric current is passed through it; a *solenoid.*

Magnetizing Turn.—One turn of a magnet coil.

Magneto.—A device for generating electricity by electromagnetic induction produced in the field of a permanent magnet. A magneto consists essentially of a permanent magnet and an armature. The magnet generates a magnetic field even when at rest. The armature is a coil of conducting wire rotating in the field of the inductor. In an automobile, magnetos are extensively used for firing the gaseous mixture.

Magneto Alternator.—An alternator in which the field is maintained by permanent magnets.

Magneto Blasting Machine.—A magneto for generating electricity for blasting purposes.

Magneto Call Bell.—In local battery telephone practice, a ringer for signaling purposes responding to currents sent out from the magneto generators at other stations. It contains a polarized electromagnet designed to move its armature according to the direction of the current sent through it.

Magneto Chemical Cell.—A voltaic cell composed of steel bar magnets with their poles immersed in a solution of oxalic acid.

Magnetod.—A name used for designating the force exhibited in animal magnetism or mesmerism.

Magneto Dynamic Force.—The electric force exerted between magnet poles.

Magneto Dynamics.—That branch of dynamics which treats of the action of magnetic force.

Magneto Electric Brake.—A device for damping a galvanometer needle, in which an inverse current is established in the galvanometer coils for the purpose of checking the swing of the needle.

Magneto Electric Faradic Apparatus.—In electro-therapeutics, a magneto for generating faradic currents.

Magneto Electric Force.—A force that a magnetic current is conceived to exert upon an electric field.

Magneto Electric Induction.—The induction whereby electricity is generated by the movement of conductors and permanent magnets past each other.

Magneto Electricity.—Electricity produced by the induction between magnets and conductors moved past them.

Magneto Electric Medical Apparatus.—In electro-therapeutics, a magneto for producing alternating currents.

Magneto Generator.—A mechanical source of electric current; usually called a *magneto.*

Magnetogram.—An automatic record of the movements of a magnetic needle.

Magnetograph.—An instrument for recording the variations of any of the earth's magnetic elements.

Magneto Ignition.—In internal combustion engines, especially for motor cars, the use of a magneto for producing the electric current required to ignite the gaseous mixture.

Magneto Inductor.—The rotor, or revolving part on a stationary armature magneto. It consists of cylindrical segments of soft iron supported and carried by a shaft located at the center of the circle described by the segments. The magnetic condition of the armature core depends upon the position of the inductor. The latter may be constructed: (1) To revolve continuously, or, (2) to rotate to and fro through a small arc by link connection, as is done in one of the numerous ignition systems for internal combustion engines.

Magneto Instrument.—A telegraph instrument operated by magneto-electricity.

Magnetometer.—An instrument for measuring the intensity of magnetic force, especially that of terrestrial magnetism.

Magnetometry.—The science of measuring the intensity of magnetic fields, especially the intensity of the earth's magnetism, by the use of the magnetometer.

Magneto-motive. — Producing magnetic flux.

Magneto-motive Force.—A force, analogous to electromotive force, which produces magnetic flux; it is measured by the work done in moving a unit magnet pole through a magnetic circuit. It is abbreviated, M. M. F. Its unit is the *gilbert.*

Magneto-motive Intensity.—The degree of magnetic pressure, or the difference of magnetic potential between the poles of a magnet.

Magneto Motor.—A motor having its field maintained by permanent magnets.

Magneto-optic Rotation.—The rotation of light produced by the passage of a polarized beam of light through a transparent medium in a magnetic field; magnetic rotary polarization.

Magneto-optics.—That branch of physics which treats of the effects produced upon light rays in passing through a magnetic field or when reflected from the surface of a magnet.

Magnet Operation. — The removal of metallic particles from the eye by the use of a magnet.

Magnetephone.—An apparatus for increasing the volume of sound, consisting of a horseshoe magnet in front of which is a perforated iron disc, and on the other side a small induction coil connected with a telephone.

Magneto Pointer.—The index of a dial telegraphic instrument.

Magneto Potential Regulator.—A form of stationary induction apparatus consisting of a coil in shunt and a coil in series with the circuit so arranged that the ratio of transformation between them is variable at will, and in which the direction of the magnetic flux, with respect to the coils, is adjustable.

Magneto Receptive Device.—An instrument actuated by a magnetic flux.

Magnetoscope.—An instrument or device for detecting the presence of magnetic force, without measuring its intensity.

Magneto Signals.—Signals given by magneto electricity.

Magnetostatic Ammeter.—An ammeter having its field produced by permanent magnets.

Magnetostatics.—That branch of physics which treats of stationary magnetic phenomena.

Magnetostatic Screening.—The act of protecting a body against the disturbing effects of stationary magnetic forces, by the use of a screening device.

Magneto Telephone.—A form of telephone employing a magneto transmitter. This type is no longer used in the U. S., having been supplanted by the microphone transmitter.

Magneto Therapy.—The use of magnets in the treatment of disease.

Magneto Transmitter.—A telephone transmitter provided with a magneto call bell which consists of two parts, the generator for sending out signals, and the ringer, or bell, for receiving signals.

Magnet Stone.—Magnetite, the magnetic ore of iron, a chemical combination of iron with oxygen, possessing the power of attracting iron as a natural magnet; the *lodestone.*

Magnet Winding.—The coils of wire wound upon the field magnets of a dynamo or motor, thereby providing a large number of magnetic lines for the armature to cut in its rotation.

Magnet Wire.—Insulated wire for use as magnet coils.

Magnus's Law.—A law of thermo-electricity stated by Magnus, that in a homogeneous circuit, *the temperature may vary from point to point, without producing any current.*

Magpie Cable.—A telephone cable containing double pairs of conductors.

Mahler's Calorimeter.—A device for testing the heating value of coals. It

consists of a strong steel vessel or *bomb*, immersed in water, and protected against radiation. One gram of the coal to be tested, is placed in a platinum boat within the bomb, and then oxygen gas is introduced under a pressure of twenty to twenty-five atmospheres. The coal is then ignited explosively by an electric spark. The heat of combustion is absorbed by the surrounding water, and its quantity is determined by the rise in temperature of the water, corrections being made for the heat capacity of the apparatus itself. The accuracy of the apparatus is such that duplicate tests will not vary more than two parts in one thousand.

Mahogany.—A tree found in Central America and the West Indies whose wood is highly valued; it is of a rich reddish or yellowish brown color, sometimes of figured grain, and hard enough to take a beautiful polish.

Main.—1. One of the principal conductors in a system of electric light or power distribution.

2. A principal pipe; as, in a gas or water-works system, through which a locality is supplied, *branches* leading off to various side streets, from which again *supply pipes* lead to individual buildings.

Main Battery.—In telegraphy, the battery employed in the operation of the main line.

Main Battery Circuit.—In telegraphy, the main circuit including the main battery.

Main Circuit Fuse.—A safety fuse inserted within a main circuit.

Main Circuit Switch.—A switch belonging to a main circuit.

Main Current.—In telegraphy, the current operating the line circuit.

Main Cut Out.—A cut out connected with a main conductor.

Main Feeder.—In a system of electrical distribution, a principal feeder through which the pressure of the system is regulated; a standard feeder.

Main Fuse.—A safety fuse inserted within a main circuit.

Main Line Relay.—In telegraphy, a relay connected with the main line.

Main Line Sounder.—In telegraphy, a sounder connected with the main line.

Mains.—In a system of electric light or power distribution, the principal conductors to which the lamps and motors are directly connected.

Main Switch.—1. A switch in the circuit of a main conductor.

2. A primary switch controlling secondary switches.

Maintenance.—The upkeep of electric apparatus or installations for the proper performance of their work. Repairs, cleaning and inspection are a part of the maintenance.

Main Terminals.—The points at which connection is made between any electrical apparatus and the external circuit.

Main Trunk Line.—A main telephone line connecting one city with another, and serving as the principal member through which the system of communication is conducted and extended.

Main Tubes.—In an underground conduit system, the tubes carrying electric mains.

Main Voltmeter.—A voltmeter for measuring differences of potential in electric mains.

Main Wire.—1. A wire forming the conductor in a main or line circuit.

2. A wire serving to make up an *electric main.*

Major Axis.—The longer axis of a body, real or imaginary, passing through it on which it may be supposed to revolve.

Make.—To cause a circuit to be completed or *closed.*

Make and Break.—To alternately close and open a circuit.

Make and Break Ignition.—Electric ignition of explosion motors, effected by bringing two platinum points together and then separating them, thus forming an arc or electric spark. The points are brought together by mechanical means, and separated by a spring, a low tension current being employed which is derived from either a primary or a storage battery.

While it is possible to produce a spark by simply breaking a low tension circuit, it is necessary in order to have a spark of sufficient intensity and duration to introduce into the circuit a *primary induction coil,* which consists of a long iron core wound with a considerable length of low resistance insulated copper wire; the length of the core

and the number of turns of the wire determining the efficiency.

When a magneto is used, a coil is not necessary as the armature winding serves the same purpose.

In make and break ignition a considerable interval of time is required for the current to rise to its full value, hence the time of separation of the platinum points should not occur sooner than the moment when the maximum current strength has been obtained. Make and break ignition is also called *low tension ignition*

Make Induced Current.—A temporary electric current which is induced by a current in its own circuit upon making or closing the circuit. Also called *inverse current.*

Making Earth.—Connecting a telegraph circuit to the earth; *grounding.*

Making the Primary.—Closing the circuit of the primary coil of a transformer.

Making Up Batteries.—Joining up voltaic cells to form electric batteries.

Malacca Tin.—A metal also called *Banca tin* and *Straits tin.* It is sold in pyramids weighing about one pound each.

Malachite.—A double carbonate and hydrate of copper, found in many places, especially in Siberia. A very valuable copper ore, but used as an ornamental stone on account of its beautiful green color.

Manage.—To control, regulate or direct the movements of an enterprise, shop, railway or the like.

Management.—Those collectively who manage any business, institution or the like.

Manager.—One who manages; a director. Shop management may properly include as its field of operations, a vast establishment with thousands of skilled and unskilled workmen, with their gang bosses, foremen, and superintendents of departments, the whole animated and directed by a *general manager*, who in turn is responsible to a board of directors, representing the capital employed.

Mandrel.—In underground cable construction, a metallic cylinder used to insure proper alignment in laying a single duct conduit by being drawn through the duct as each section is laid on.

Manganese.—A metal resembling and possessing a remarkable affinity for iron. It is generally found in the form of oxides, and is widely used as a chemical reagent and oxidizer. Conjointly with hydrochloric acid, it evolves chlorine gas; combined with chlorate of potash and caustic potash, it forms permanganate of potassium, a well known disinfectant; is added to steel to neutralise phosphorus, and also has the valuable property of rendering that metal *non-magnetizable.*

Manganese Bronze.—A very durable alloy of copper and tin with some ferromanganese. It is capable of being cast into delicate and intricate shapes and is largely used in complicated machinery, as in automobile parts. It has also the advantage of resisting sea water corrosion.

Manganese Copper.—An alloy of 30 parts, by weight, of manganese and 70 parts copper, employed for electric conductors.

Manganese Dioxide or Binoxide.—A chemical compound of manganese and oxygen. It occurs in nature crystallized in prisms with a silver luster. In this state it is called *pyrolusite.* In a powdered form, it is known as *black oxide of manganese,* and when mixed with plumbago it is used as a depolarizer in the Leclanche cell and in dry batteries.

Manganese Steel.—A mixture of steel with the metal manganese, producing an alloy of greater toughness and strength than ordinary steel.

Manganin.—An alloy of manganese, copper and nickel, having a small resistance temperature coefficient, and, therefore, useful in making standard resistance coils.

Manganin Resistance.—A resistance coil composed of the alloy manganin.

Mangin Projector.—A form of projector for searchlights provided with a concavo-convex mirror reflector having its convex surface silvered, and so adjusted that the light undergoes two refractions.

Manhole.—1. In an underground conduit system, a vault built under the street, having a circular opening at the street surface covered by a cast iron cover, and large enough to conveniently admit a man, so that access may be had to the conduit ducts and the cables.

2. An opening by which to enter a steam boiler, tank, sewer, aqueduct, or the like, for cleaning, repairing, or inspecting.

3. A side excavation or refuge in tunnels.

Manifold.—A connection with numerous branches used to convey fluids between a large pipe and several smaller ones.

Manila Hemp.—A fiber of the same genus as the banana. When dressed it is of two qualities, the finer being made into handsome shawls, the coarser into ropes; as, *manila rope.*

Manograph. — An apparatus sometimes called the *optical indicator* for taking indicator diagrams of gas engines. The diagram is traced by a beam of light reflected upon a ground glass screen, or on a photographic plate by a mirror which oscillates at the same time on both a vertical and horizontal axis.

Manometer.—1. An instrument, consisting essentially of a bent tube partly filled with mercury, for measuring the pressure of gases.

2. A general term including all varieties of pressure gauges, such as tube, spring, syphon and mercurial types.

Manometric Flames.—A peculiar effect is produced on a flame by sound waves. Koenig's apparatus for indicating small variations of air pressure, by its effect on a flame, consists of a metal "capsule" or box, divided into two chambers by an elastic diaphragm. At one end is an orifice for the admission of sounds from the voice or an instrument, and at the other is an ordinary gas burner, gas for which is admitted to the chamber in front of the diaphragm. If the gas be lighted and its supply be agitated by the sound waves striking against the diaphragm the flame will undergo perceptible changes in strength and steadiness. These may be seen to advantage by taking a four-sided box with mirrors on every side and turning it rapidly in front of the flame. The resulting "image" will differ according to the strength, timbre and other characteristics of the sound.

Manual.—Of or pertaining to the hand; done or made by the hand; as, *manual* labor.

Manual Alarm.—An alarm operated by hand.

Manual Igniting Device.—Any device for lighting a gas jet, or exploding a blast, operated by hand.

Manual Power.—The muscular power of men's arms. The mean effect of a man's power, unaided by machine, is the raising of 70 pounds 1 foot in one second, or 4200 foot pounds per minute for 10 hours a day. Two men working at a windlass with the handles at right angles to each other, can raise 70 pounds more easily than one man can 35 pounds.

Manual Repeater.—In telegraphy, a repeater or translator operated by hand, instead of mechanically, as the automatic repeater.

Manual Telegraphy.—Telegraphic transmission by hand, as distinguished from automatic telegraphy.

Manual Translation. — Repeating or translating a telegraphic message to another circuit by hand as the signals are received over the first circuit.

Manufacture of Carbons.—There are various ways of preparing artificial carbons; graphite, derived from gas retort carbon, usually forms the basis. This is ground up and well mixed with pure carbon powder derived from the destructive distillation of some such organic substances as gas tar, pitch, or albumen. An adhesive substance, such as a syrup of sugar cane and gum, is then added to make a paste. The rods are shaped either by moulding, squeezing, or forcing the mixture with considerable pressure through a die plate. Rods so formed, are baked several times in an oven and immersed in a syrup between each baking. The chief requirements of a carbon rod are, that it should be dense and pure, and that its electrical resistance should be low.

Maple.—A tree common in the temperate zone all over the globe; valued both for its shade and ornamental effect, as well as for its wood. There are over fifty species; bird's eye maple is highly valued for cabinet finish.

Marble.—A kind of limestone of varying color and markings capable of taking and retaining a high polish. It is largely used for switchboard panels because of its good insulating qualities.

Marconi, Guglielmo.—Born 1874. An Italian electrician; the first to successfully apply the principle of the Hertzian waves to telegraphy in the invention of the Marconi system of wireless telegraphy (1895). In 1899 he established wireless communication between France and England across the English Channel; in 1901 transmitted signals across the Atlantic from Cornwall to Newfoundland, a distance of 2100 miles; in 1902 established communication between Canada and England, and a few weeks later between Cape Cod and Cornwall; and established transatlantic wireless service for public use in 1907. His system is used by the principal shipping companies in America and abroad and in the British and Italian navies.

Marconi Waves.—Electromagnetic waves set up in the ether by the Marconi system of wireless telegraphy.

Margin.—In building, the exposed portion of a slate, tile or other roof covering. The width of the margin is known as the *gauge*, the part covered by the next higher is the *cover*, the part which overlaps the next lower is the *lap* or *bond*.

Margin of Relay Adjustment.—The limits within which the armature of a telegraph relay may be usefully adjusted.

Margin of Safety.—A shop term, signifying *factor of safety*.

Marine Compass.—A form of magnetic compass, suspended in such a manner that it will remain as horizontal as possible during the motion of the ship. Since modern ships are constructed largely of metal, the magnetic effects thus set up are corrected by fixing compensating masses of iron in suitable positions. The marine compass is also called *mariner's compass*.

Marine Galvanometer.—A form of galvanometer specially adapted for use on shipboard.

Marine Glue.—A glue composed of india rubber, shellac, and a solvent oil, such as coal tar naphtha; it is applied hot to canvas, wood, etc., where a water-tight joint is desired.

Marine Junction Box.—A junction box for electrical connections, of special watertight construction suitable for use on shipboard.

Marine Lamp Socket.—An incandescent lamp socket designed to give the required flexibility to a lamp on a ship.

Mariner's Compass.—In navigation, an instrument for determining direction. It consists, in its simplest form, of a magnetic needle suspended upon a pivot and attached to a card marked with thirty-two points of direction. These points of the compass are also called rhumbs. The glass covered case containing the compass is supported upon gimbals in order to preserve a horizontal position.

Marine Searchlight.—A light for the use of warships and other vessels.

Marine Switch.—A switch of special watertight construction for use in electric circuits on shipboard.

Marine Voltmeter.—A voltmeter adapted to electric installations on ships.

Mark Buoy.—A buoy used in submarine cable operations for merely staking out a position, and not, like the cable buoy, for securing the cable.

Marked End or Pole.—The north pole of a magnet, so called because it is usually marked to distinguish it from the south pole.

Markers.—Signal lights and flags employed in the block system for railroads.

Marking Current.—In double current automatic telegraphy, the current which completes the local circuit and records the dots and dashes of the message, as distinguished from the spacing current.

Marking Disc.—In Morse's system of writing telegraphy, a metal disc which rotates against the ink roller and records the message upon the paper strip.

Mariotte's Law.—*The volume of a gas is inversely proportional to its (absolute) pressure at constant temperature.* Expressed as a formula:

$$p\,v = p'v'; \text{ or } p\,v = \text{a constant}$$

in which, p = pressure at a volume v, and p' = pressure at a volume v'. The constant varies with the temperature, everything else remaining. Air compressed to seventy five atmospheres, has a volume about two per cent less than that computed by Mariotte's law. This law is also known as *Boyle's law*.

Mass.—The quantity of matter which a body contains, the *weight* of the body being the measure of the earth's pull or the force of gravitation upon the mass. The mass of a body is a constant quantity while the weight varies according to the variation in the force of gravity at different places.

If g=the acceleration due to gravity, w=weight, and m=mass, then:

$$m = \frac{w}{g}$$

from which

$$w = m\,g.$$

Mass Attraction.—The universal attraction which all bodies exert upon one another.

Mass, Electric.—A term applied to the quantity of electricity mathematically considered as corresponding to masses of matter.

Massicot.—The yellow oxide of lead. It does not differ chemically from litharge though different in color and mechanical condition. When the massicot is melted it has a reddish tint and is called litharge.

Mast.—In wireless telegraphy, a lofty pole for supporting the sky rods or antennæ by means of which electromagnetic waves are both transmitted and received.

Mast Arm Bracket.—A long arm, attached by a hinge to a supporting pole, for suspending an arc lamp over a street, and allowing the lamp to be raised and lowered for the purpose of cleaning and renewing the carbons.

Mast Compass.—A compass supported by a ship's mast at such a height as to minimize the effect of the vessel's magnetic attraction.

Master Clock.—The standard clock which controls the movement in dependent clocks in a system of electric timekeeping; the primary, or controlling clock; a telegraphic clock.

Mast Winch.—In rigging, a hoisting machine either worked by hand or power and secured to a ship's mast; or a *pillar* in shop use. It may have single, double or treble, gearing with brakes and other improvements.

Mat.—In electroplating, a dead or dull finish obtained by leaving the metal unburnished after it has been deposited.

Mate of Wire.—The second wire twisted with a first to make a twisted pair.

Mathematics.—That science which treats of the exact relations existing between quantities or magnitudes. The science of quantities is afterwards divided into pure and mixed mathematics. The branches of pure mathematics are arithmetic, geometry, algebra, analytical geometry, and the differential and integral calculus: the three latter embrace the entire portion of mathematical science in which quantities are represented, not by numbers, but by letters of the alphabet.

Matte.—An impure metal obtained in the smelting of various ores; as, copper or silver. Called also *coarse metal.*

Matter.—Any collection of substance existing by itself in a separate form; matter appears in various forms which, however, can all be reduced to three classes; namely, *solids, liquids, gases;* a *solid* offers resistance to change of shape; it has a fixed form and is hard, firm and compact. A liquid is a substance which flows and can be poured in drops, like water. A liquid flows, and wets that on which it flows. A gas is a fluid form of matter which is elastic and tends to expand indefinitely. A term used at first by chemists as synonymous with air, but since restricted to fluids supposed to be permanently elastic; as, oxygen, hydrogen, etc., in distinction from vapors, as steam, which become liquid on a reduction of temperature.

The two *essential* properties of matter, both of which are inseparable from it, are extension and impenetrability. Extension, in the three dimensions of length, breadth and thickness, belongs to matter under all circumstances; and impenetrability, or the property of excluding all other matter from the space which it occupies, appertains alike to the largest body and the smallest particle.

Matter, Electric.—A term formerly applied to the imaginary effluvium supposed to account for electrical phenomena.

Matteucci, Carlo.—Born 1811, died 1868. Italian physicist; was several times minister of public instruction, and also member of the Florence council of education. As professor of physics at Pisa, he made many experiments and discoveries in animal electricity, and published Manuale di Telegrafia Electrica (1850).

Matteucci's Muscle Pile.—A voltaic pile composed of muscular tissues cut from animals and laid one upon another, so that the interior surface of one piece comes into contact with the exterior of the next, thereby generating an electric current sufficient to deflect the needle of a galvanometer.

Matthiessen, Augustus.—Born 1831, died 1870. An English chemist and physicist, distinguished for his researches in the electrical conductivity of metals and alloys, and for the construction of electrical standards (1860-65).

Matthiessen's Meter Gram Standard.—A standard of resistance in wire, being the resistance offered by one meter of pure copper wire of a diameter such as to weigh one gram per meter, and equal to 0.1417 international ohm at 0° C.

Matthiessen's Unit of Resistance.—A standard of resistance equal to that of a mile of pure copper wire, one-sixteenth inch in diameter at a temperature of 60° F.; *a mile standard.*

Mattress.—In hydraulic engineering, a mat woven of brush, poles, etc., used in pro-

tecting embankments, forming dykes, jetties, etc.

Maturing of Call.—When several calls have been recorded at a telephone exchange to be answered in the order of receipt, the time when any call has reached its turn.

Maximum.—The highest value considered with respect to other values.

Maximum Activity of Motor.—The highest point of useful activity to which a motor can attain; *the full load efficiency.*

Maximum Efficiency of Transformer.—The efficiency of a transformer when working at full load; *the full load efficiency.*

Maximum Horizontal Intensity of Light.—The greatest intensity of light measured in a horizontal direction from its source.

Maximum Magnetization.—The state of a magnet which has reached magnetic saturation or the highest degree of magnetism to which it can attain.

Maximum Negative Elongation.—The extreme limit which a vibrating body reaches in the negative direction.

Maximum Positive Elongation.—The extreme limit which a vibrating body reaches in the positive direction.

Maximum Pressure.—The utmost pressure which is brought to bear upon the body of a structure. Commonly it has reference to the pressure of elastic fluids and liquids.

Maximum Starting Current.—The greatest value reached by the starting current of a motor.

Maximum Traction Truck.—An extreme size of truck for railway cars.

Maximum Value of Alternating Current Wave.—The amplitude or the value of the alternating current taken at the top of the wave.

Maximum Value of E. M. F.—In an alternating current circuit, the pressure when considered at *the top of the alternating current wave.*

Maxwell.—The unit of magnetic flux. It is the amount of magnetism which passes through every square centimeter of a field of unit density.

Maxwell, James Clerk.—Born 1831, died 1879. A Scottish physicist and writer on electrical and physical subjects. In 1857 he obtained a prize for an able essay on Saturn's rings. He was the author of the kinetic theory of gases (1860), and he gained the Rumford medal the same year for his discussion of colors in relation to color blindness. He is best known, however, for his researches in electricity and magnetism, beginning in 1856 with his paper on "Physical Lines of Force" and culminating in his great "Treatise on Electricity and Magnetism" published in 1873. He propounded (1873) the electromagnetic theory of light, founded the science of electro-optics, and advanced the conception of electromagnetic waves, by which he laid the foundation of the science of wireless telegraphy.

Maxwell's Electromagnetic Theory of Light.—A theory propounded by Maxwell, that, since luminous and electromagnetic waves are transmitted with the same velocity in the same medium, light itself is an electromagnetic phenomenon.

Maxwell's Rule.—A rule formulated by Maxwell for determining the mutual action of an electric circuit and a magnet placed near it, as follows:

Every portion of the circuit is acted upon by a force urging it in such a direction as to make it enclose within its embrace the greatest possible number of lines of force.

McIntire Sleeve Joint.—A method of joining wires in which a sleeve is used consisting of two copper tubes soldered together, and having bores corresponding to the size of the wires to be joined; the ends of the wires being inserted by a special tool the whole is twisted together, no solder being required.

M. Current.—A contraction for *mean current.*

Mean Annual Station Current.—The average electric current output of a station during the year.

Mean Current.—1. The average of current strength for a given time.

2. In an alternating current, the mean square of its varying values, independent of the sign of the current.

Mean Effective Value.—In alternating current calculations, a value representing a constant quantity which would produce the same working effect as the varying quantity; the *virtual* value.

Mean Electromotive Force.—1. The average electromotive force for a given time.

2. In an alternating current, the square root of the mean square of the varying values of the actual electromotive force.

Mean Hemispherical Candle Power.—In electric lighting, the average candle power in every direction in a hemisphere having the light source at its center.

Mean Horizontal Intensity of Light.—The average intensity of light in a horizontal direction from its source.

Mean Illumination.—The average quantity of light received per unit area of illuminated surface.

Mean Load Current.—The electric current delivered under an average load.

Mean Quadratic Current.—A term applied to an average intensity of alternating current.

Mean Spherical Candle Power.—An average of spherical candle power.

Mean Temperature.—The average temperature observed at a particular place over a number of years; generally noted as annual, or for any particular season or month.

Measurement of Light.—Light can be measured with great accuracy, owing to an invariable law which is similar to the law of gravitation. *The intensity of light is as the square of its distance;* thus, if two lights of unequal power be made to shine on the surface of a smooth plaster wall, and a book or card be interposed, the two shadows produced by the crossing of the rays will differ in blackness in the same degree as the powers of the two lights: the stronger light will produce the darker shadow. To obtain the difference in power of the two lights, the stronger light must be moved backward or the lesser light forward until both shadows are the same tint, which the eye can tell with great exactness.

Measurements, Electrical.—Measurements of the various effects exhibited in electrical phenomena, especially practical measurements in connection with the electric circuit.

Every system of measurement is based upon some experimental fact or law. An electric current can: 1, cause a deposition of metals from their chemical solutions; 2, heat the wire that it flows through; 3, attract (or repel) a parallel neighboring current; 4, accumulate as an electric charge that can repel (or attract) a neighboring charge of electricity; 5, produce in its neighborhood a magnetic field, that is to say, can exert a force upon the pole of a magnet placed near it, as for example, in galvanometers. This last is made the basis in the system now adopted by international agreement; and it is the best because, firstly, it connects the electrical units with the magnetic ones, and secondly, it is closely connected with the mechanical units, enabling the mechanical values of the electrical quantities to be readily computed.

Instruments for measuring currents of electricity are of many styles. As a mysterious and invisible element is dealt with, the measurement is indirect. The effects of currents of various pressures and volumes are what are measured, not the currents themselves.

Measures.—Measures are of seven kinds: 1. Length; 2. Surface or area; 3. Solidity or capacity; 4. Weight or force of gravity; 5. Time; 6. Angles; 7. Money or value.

Measuring Current.—The electric current used as basis of electrical measurements.

Measuring Tape.—A narrow tape or ribbon enclosed in a circular casing from which one end is drawn out as required for measurement. Tapes vary from 25 to 100 feet in length and are made of linen strengthened with wire, and also of ribbon steel. Tapes alter in length with the moisture in the atmosphere, but should not be more than ½ inch out of their total length at any time. They are used for outdoor work, for taking circumferences or arc measurements of large pieces of work.

Mechanical Air Pump.—A machine for pumping air. *A vacuum pump.*

Mechanical Characteristic of Motor.—A characteristic curve in which the torque and speed of a motor are taken as co-ordinates.

Mechanical Circuit Closer.—A mechanism for closing a circuit, operated without the aid of electricity.

Mechanical Cut Out.—A cut out which acts mechanically instead of electrically.

Mechanical Depolarization.—A method of preventing polarization of a voltaic cell by merely agitating it, or by lifting the cathode plate now and then into the air.

Mechanical Draft.—Artificial draft for furnace fires obtained by mechanical means. Mechanical draft is not only employed as a supplement to chimney draft but often as a substitute for it. It may be produced by means of steam jets inducing a flow of air, by blowing engines, by air

compressors, by positive rotary blowers, and by fan blowers or exhausters.

Mechanical Effects in Dielectric.—According to Siemens, the glass of a Leyden jar is warmed after being several times rapidly charged and discharged, from which it would appear that the changes of stress in the dielectric are accompanied by a molecular movement. Nothing is known as to the precise nature of the molecular or mechanical operations in the dielectric when subjected to an electrostatic inductive stress. A click, similar to that heard when an iron bar is magnetized, is audible when a Leyden jar is discharged.

Mechanical Effects of Discharge.—The discharge of electricity from a conductor is influenced somewhat by the shape of the terminals when the discharge takes place. An electric machine capable of giving a long spark when the knuckle is presented to the knob, will, on fastening a needle to the conductor, discharge the electricity so effectually at its point that only very short sparks can be drawn at the knob, while a fine brush or jet of pale blue light will appear at the point. An air current is set up of sufficient intensity to blow aside the flame of a lighted candle when brought near. The air current can be felt by the hand and is due to a mutual repulsion between the electrified air particles near the point and the electricity collected on the point itself.

Mechanical Effects of Magnetization.—It was discovered by Joule that a bar of iron will increase $\frac{1}{720000}$ of its original length when magnetized, and according to Bidwell, it will contract again when highly magnetized. When rods are stretched by a weight, they contract more when magnetized, than do unstretched rods.

Another mechanical effect of magnetization, is the faint metallic click heard when a bar is either magnetized or demagnetized. Magnetism is accompanied by internal friction, as is evident by the heating of a bar when magnetized and demagnetized in rapid succession.

Sir W. Grove showed that water containing finely divided magnetic oxide of iron, becomes clear on magnetizing in the direction of the magnetization, indicating that the particles of iron set themselves end-on, thus allowing more light to pass between them. A piece of iron when twisted, tends to untwist on being powerfully magnetized.

Mechanical Equivalent.—A heat unit; the mechanical energy equal to the heat necessary to raise 1 lb. of water 1 degree Fahr. Discovered by James Prescott Joule of Manchester, it was given a value of 772 foot pounds, but many further researches have given the value of 778 foot pounds as the mechanical equivalent.

Mechanical Equivalent of Heat.—1. The amount of work which a unit of heat can perform.

2. The mechanical energy required to raise the temperature of a unit weight of water one degree; also called *Joule's equivalent.*

Mechanical Equivalent of Light.—The amount of mechanical energy in a unit quantity of light.

Mechanical Friction of Dynamo.—The friction of the bearings, armature brushes, and other moving contacts of a dynamo.

Mechanical Magnet Lightning Arrester.—A lightning arrester with a mechanism operated by an electromagnet.

Mechanical Mine.—A submarine mine provided with such mechanism that an explosion results from the impact of a colliding vessel.

Mechanical Powers.—These are six in number: 1. The lever. 2. The wheel and axle. 3. The pulley. 4. The inclined plane. 5. The screw. 6. The wedge.

Mechanical Recorder Meter.—Any meter registering mechanically.

Mechanical Sealing.—A mechanical method of sealing the bulb of an incandescent lamp after the air has been exhausted from it.

Mechanical Stoker.—An apparatus constructed to feed and stir the fire automatically, thus relieving the firemen. The principal parts of the machine are: (1) The hopper, which may be filled either by hand shoveling or by elevating and conveying machinery; (2) the conveyor screw, which forces the coal, or indeed, any description of fuel, forward to, (3) the magazine, (4) a driving mechanism, which is a steam engine arranged conveniently in front of the hopper, (5) the retort, so called from its being the place (above the conveyor) where the coal is distilled into gas.

Mechanical Telegraph.—A form of automatic telegraph in which the paper ribbon bearing the dots and dashes of the message passes under a key or stylus, and mechanically makes and breaks the circuit as it passes through.

Mechanical Telegraphic Interrupter.—A simple mechanical sounder employed as a practice instrument for learners in telegraphy.

Mechanical Telephone.—A simple device for conveying conversation a short

distance along a wire or string by mere mechanical vibrations; a toy telephone.

Mechanical Theory of Heat.—In physics, heat and mechanical force are said to be identical and convertible. Independently of the medium through which heat may be developed into mechanical action, the same quantity of heat is resolved into the same quantity of work.

Mechanical Torpedo.—A torpedo which is exploded by the impact of collision.

Mechanical Vibrator.—A make and break mechanism acting mechanically.

Mechanical Work.—Work is the product of a force by the distance through which it acts to produce motion. The unit of work is the *foot pound*, or the work done in raising one pound, one foot. In the C. G. S., or absolute system of physical measurements, the unit of work is the *erg*, being the work done in overcoming a force of one *dyne* through a distance of one *centimeter*.

Mechanics.—1. The theory of machines.

2. The science dealing with forces and their action upon matter. This is the modern view of the science, and it is usual to regard mechanics as divided into two branches: *kinematics* and *dynamics*. The former treats of motion alone without reference to the forces which produce those motions, the latter is sub-divided into *statics* and *kinetics*, the first dealing with forces acting upon bodies at rest, the second with moving bodies.

Medical Battery.—A form of induction coil in combination with a current source, employed in the medical application of electricity. It is always of low power so that the maximum E. M. F. generated in the secondary shall not be dangerous to the patient.

Medical Electricity.—The application of electricity in the treatment and cure of disease; electro-therapeutics. Discontinuous currents are employed to stimulate the nerves in paralysis and other affections. In restoring persons from drowning, electricity may be used to assist the contraction of the diaphragm and chest muscles in order to start respiration.

Continuous currents, which produce a sedative effect around the anode, are of value in cases of neuralgia and other painful affections, also useful to disperse tumors. The nerves are stimulated by alternate currents as well as by rapidly interrupted uni-directional currents.

Medical Induction Coil.—In electrotherapeutics, an induction coil suitable for producing faradic currents.

Medical Magneto Generator.—In electro-therapeutics, a small magneto for producing faradic currents.

Meg or Mega.—A prefix to a unit of measurement to denote one million times that unit.

Mega-dyne.—A unit of force equal to *cne million dynes.*

Mega-joule.—A unit of electrical energy equal to *one million joules.*

Megalascope, Electric.—An instrument provided with a magnifying apparatus, for the medical examination of the internal cavities of the human body.

Megaline.—A convenient term employed in considering lines of electromagnetic flux. A megaline being equal to *one million lines.*

Mega-volt.—A unit of electromotive force equal to *one million volts.*

Mega-weber.—A unit of magnetic flux equal to *one million webers.*

Megerg.—A unit of work equal to *one million ergs.*

Megohm.—A unit of electrical resistance equal to *one million ohms.*

Megohm Box.—A resistance box provided with coils capable of offering a resistance of one million ohms.

Megohmit.—An insulating material which is prepared in various forms, viz.: (a) thin sheets of mica built up with shellac, called *hard megohmit*; (b) sheets of mica stuck together by vegetable adhesives, called *flexible* megohmit; (c) flexible megohmit covered with Japanese paper, called *mica paper*; and (d) flexible megohmit covered with linen, called *mica linen.*

Megohm Mile.—An insulation resistance in wire equal to a megohm per mile.

Melting of Electric Conductor.—The fusing of a conductor owing to excessive electrical heat.

Melting Point.—The temperature at which a substance begins to fuse, that is, to change from a solid to a liquid state. The melting points of a few well known substances are as follows:

TABLE.

Mercury.........	39° F	Tin.....	442 to 446° F
Ice.............	32	Lead....	608 to 618
Tallow..........	92	Silver...	1733 to 1873
Wax......	142 to 154	Copper..	1929 to 1996
Sulphur.........	239	Steel....	2372 to 2532
Alloy, 1 tin, 1 lead	370 to 466	Wrought Iron	2732 to 2912

Membrane Diffusion.—When two different liquids are separated from each other by a membrane or other porous partition, there arises a tendency for the liquids to pass through the membrane. This diffusion through a membrane is usually termed *osmose* or *osmosis*.

Membrane Telephone Receiver.—A primitive form of telephone receiver employing a membranous diaphragm.

Mensuration.—The art of measuring things which occupy space; the art is partly mechanical, and partly mathematical, hence can be illustrated with drawings to aid in the better understanding of the arithmetical problems connected with it.

M. E. P.—Abbreviation expressing the *mean effective pressure* of the steam in the cylinder of an engine. It is the mean forward pressure, less the mean back pressure.

Mercurial Air Pump.—An exhausting pump which depends for its action upon the formation of a vacuum at the top of a barometer tube by the flow of a column of mercury. The most effective form is the *Sprengel pump*.

Mercurial Commutation.—Changing the direction of an electric current through a mercurial contact.

Mercurial Contact.—An electrical contact made by the use of mercury.

Mercurial Phosphorescence.—A term formerly applied to the fluorescent light of a column of mercury in a vacuum tube.

Mercurial Temperature Alarm.—An apparatus for giving alarm by the use of a mercury contact under given increase of temperature.

Mercurial Thermometer.—Consists of a stem or tube of glass, formed with a bulbous expansion at the foot to contain the mercury which expands into the tube. A sufficient quantity of mercury having been introduced, it is boiled to expel air and moisture, and the tube is hermetically sealed. The freezing and the boiling points on the scale are then determined, respectively, by immersing the thermometer in melting ice, and afterwards in the steam of water boiling under the mean atmospheric pressure, 14.7 pounds per square inch, and finally marking the two heights of the column of mercury in the tube. The interval between these two points is divided into 180 degrees for Fahrenheit's scale, or 100 degrees for the Centigrade scale, and degrees of the same interval are continued above and below the standard points as far as may be necessary.

Mercurial Thermostat.—An apparatus for closing an electric circuit by means of a mercurical contact effected by the expanpansion of mercury when heated.

Mercury.—Often known as *quicksilver*. A silvery white metal; melts at 39° and boils at 358° F. It unites with oxygen at a temperature near its boiling point forming crystalline red oxide, and unites with many substances even at the ordinary temperature. Combinations with other metals are called *amalgams*. Mercury is largely used in thermometers, barometers, air pumps, standard cells and other electrical apparatus. It is a good conductor of electricity.

Mercury Air Pump.—A pump for producing a vacuum, consisting essentially of a small vertical tube leading from a reservoir of mercury at its top, the vessel to be exhausted being attached to the side of the tube near the top, so that the suction of the falling mercury exhausts the air; the Geissler or Sprengel mercurial pump.

Mercury Arc Rectifier.—The same as *mercury vapor converter*.

Mercury Barometer.—An instrument for measuring and indicating the pressure of the atmosphere by showing the effect of the air pressure upon a column of mercury in a graduated glass tube.

Mercury Bichromate Cell.—A primary cell of the Poggendorff type, the Fuller cell being the best known representative. Mercury is employed to amalgamate the zinc electrode in a porous cup, and a solution of bichromate of potash as depolarizer surrounds the carbon in the outer jar.

Mercury Circuit Breaker.—An automatic circuit breaker employing a mercury cup; the circuit is closed and opened alternately as a connecting wire dips into and rises from the mercury.

Mercury Coherer.—In wireless telegraphy, a form of self-restoring coherer containing a plug of iron between two

plugs of carbon, with a globule of mercury in the spaces between the plugs.

Mercury Cup.—A cup or cavity filled with mercury and forming an electrode of a circuit, so that by dipping another terminal into it, a very good electrical connection is obtained.

Mercury Gauge.—Any pressure gauge in which a column of mercury is employed to give the indications.

Mercury Switchboard.—A switchboard fitted with mercurial contacts.

Mercury Vapor Converter.—A device for changing alternating into direct current, invented by Peter Cooper Hewitt. It consists of a highly exhausted glass bulb fitted with two iron electrodes in bottle shaped glass shields and two electrodes of mercury. The two external circuits of an auto-transformer are connected with the iron electrode, while the internal terminals are connected to the supply circuit. This type of converter is especially useful in charging storage batteries; also known as *mercury arc rectifier.*

Mercury Vapor Lamp.—A lamp consisting of a vacuum glass tube about an inch in diameter and four feet long, with platinum leading-in wires sealed into the ends connecting with an anode which consists of a grid or a small quantity of mercury at one end, and a cathode of mercury at the other; when an electric current is passed, the mercury is vaporized and the vapor, heated to incandescence, emits an intense light; the Cooper-Hewitt lamp.

Meridian.—Any great circle assumed to pass over the earth's surface through the poles and at right angles to the equator.

Mesh Grouping.—In a polyphase circuit, a method of winding the armature coils so that they are close together forming a closed circuit, and having the line wire attached to the points of junction between the coils.

Message Wire.—In a railway block system, a wire for sending local messages along the road.

Messenger Call Box.—A box electrically connected with a central office for calling messengers, policemen, firemen, etc. Each box has make and break attachments which are operated by turning a crank, thereby transmitting to the central office a number corresponding to that of the signaling box.

Messenger Strand.—One of the strands of a messenger wire.

Messenger Wire.—A steel rope stretched tightly between poles for the purpose of supporting aerial cables which do not have sufficient strength to support their own weight.

Messenger Wire Clamp.—A device by which a messenger wire is supported, and secured to the poles which carry it.

Metal.—An element that forms a base by combining with oxygen. It is usually a good conductor of heat and electricity; generally, hard, heavy, malleable and tenacious. Metals, as known to the ancients were: gold, silver, copper, iron, tin and lead.

Metallic Arc.—An electric arc maintained between electrodes composed of metal.

Metallic Circuit.—An electric circuit not employing a ground return; a circuit formed of metallic conductors throughout.

Metallic Circuit Plug.—A telephone switchboard plug which makes connections with a metallic circuit by double conductors, one attached to the tip of the plug, and the other to its sleeve.

Metallic Coating.—A coating or layer of metal deposited by electrolysis.

Metallic Conducting Joint.—A joint in a metallic conductor, so fitted as not to disturb its conductivity.

Metallic Conduction.—The flow of electricity through a metal conductor, as contrasted with its passage through an electrolyte or through the earth.

Metallic Connection.—An electrical connection established through conductors of metal.

Metallic Contact.—An electrical contact obtained by touching one metallic conductor with another.

Metallic Contact of Cable.—A fault in a submarine cable caused by the accidental contact of its core with its metal sheath.

Metallic Electrodes.—In electro-therapeutics, suitably shaped electrodes of metal.

Metallic Filament Lamp.—An incandescent lamp employing for its filament, instead of carbon, a thread of one of the

rare metals, such as tantalum, tungsten or osmium, which have extremely high melting points.

Metallic Reluctivity.—The reluctivity of a metallic body considered with regard to the metal apart from the ether which pervades it.

Metallic Resistance.—The resistance offered by metallic conductors.

Metallic Solution.—A liquid holding a metallic salt dissolved in it.

Metallization.—The process of applying a film of plumbago or bronze powder to a non-conducting surface in order to prepare it for the deposit in electrotyping.

Metallized Filament.—A carbon lamp filament which has been heated to an extremely high temperature in a carbon tube electric furnace before and after flashing.

Metallized Filament Lamp.—An incandescent lamp employing a carbon filament which has been subjected to an excessive heat in a form of electric furnace, so that the texture of the filament has more of the characteristics of a metal than of carbon. Metallized filament lamps operate at a much higher temperature and show greater efficiency, producing a white light, than ordinary carbon filament lamps.

Metallizing.—Applying metallization to a non-conducting surface.

Metallochromes.—Symmetrical rings of varied colors due to deposits of lead peroxide, observed by Nobili in his experiments in electrolyzing a solution of lead; *Nobili's rings.*

Metallography.—The science of examining prepared metallic surfaces under the microscope. After careful polishing and grinding to a smooth surface, the structure is brought out by etching with acid, the surface being preserved for subsequent examination by a coat of transparent varnish. By this method of investigation, the crystalline structure of metals has been demonstrated and the behavior of the molecules under stresses or hardening and annealing is made apparent.

Metalloid.—A term applied to certain elements which present both metallic and non-metallic characteristics, thus partaking of the properties of both metals and non-metals. *Antimony, arsenic* and *tellurium* are examples.

Metallurgy.—The science which treats of the reduction of metals from their ores; *electro-metallurgy.*

Metals.—The six metals known to the ancients were gold, silver, copper, tin, iron and lead, and their properties gave shape to the idea of a metal, namely: an undecomposable element possessing weight, opacity, a peculiar luster, conductivity for heat and electricity, and ductility.

Metal Voltameter.—A name sometimes given to a *silver* or *copper* voltameter which measures an electric current by the amount of metal deposited by electrolysis.

Meteoric Iron.—Masses of nearly pure iron found in various parts of the world, varying in weight from a few pounds to many tons. Containing 1 to 2 per cent of nickel, having twice as much combined hydrogen as ordinary malleable iron, and being generally oxidized outside with an unoxidized interior, it is shown to be of extra terrestrial origin, that is, it is thrown off by some other planet, or is encountered by the earth on its orbit, having formed part of one of those shoals of wandering bodies known as meteorites, which, flaming through friction with the atmosphere, become "shooting stars."

Meteorite.—A mass of stone or metal that has become detached from some celestial body and fallen upon the earth.

Meteorograph, Electric.—An apparatus for making continuous observations of meteorological phenomena and electrically recording the same, so that the changes of temperature, the direction and velocity of the wind, the height of the barometer, the rainfall, etc., are automatically and continuously registered.

Meteorology.—That branch of physics which is concerned with the study of atmospheric phenomena.

Meteorology, Electric.—That part of meteorology dealing with the electrical phenomena of the atmosphere.

Meter.—A unit of length in the metric system. It is equal to that of a standard platinum bar, kept in Paris, and representing approximately a ten-millionth part of a quadrant of the earth's meridian measured from the equator to the pole through Paris; one hundred centimeters or 39.37 inches.

Meter Bridge.—A form of Wheatstone's bridge for measuring low resistances in

which a slide wire is stretched over a scale one meter in length; a *slide wire bridge.*

Meter Candle.—A unit of illumination equal to the light of a standard candle at a distance of one meter.

Meter, Electric.—In the commercial distribution of electricity, an instrument for measuring and recording the quantity of electricity supplied to a consumer.

Meter Gram.—Matthiessen's standard of resistance in wire, being the resistance offered by one meter of pure copper wire of a diameter such as to weigh one gram per meter, and equal to 0.1417 international ohm at 0° C.

Meter Gram Resistivity.—A term denoting the electric resistance of a uniform mass one meter long, and having a weight of one gram. It is resistivity expressed in terms of length and mass.

Meter Millimeter.—A standard of resistance in wire; it is the resistance offered by a meter's length of wire having a diameter of a millimeter.

Meters.—The supply of electric current to consumers is measured by meters, of which there are several types, such as, *integrating, chemical, motor* and *retarded clock meters.*

An integrating meter consists of a clock which drives a counting apparatus through an intermediate gear operated by the current.

The principle of a chemical meter is that the current or a known fraction of it passes through an electrolytic cell and deposits copper in some types and dissolves zinc in others. The chemical action depends on the ampere hours.

In a motor meter, the current passes through the armature of a small motor which has a constant field.

The speed of the motor is controlled by fluid friction and is proportional to the intensity of the current. A suitable counting gear attached to the motor indicates the ampere hours.

A retarded clock meter operates by the action of the current on the clock movement. The current flows under a magnetic pendulum bob. Any force thus added or subtracted from gravity will cause the clock to gain or lose.

Meter Sealing Tool.—A tool for applying a lead seal to an electric meter to prevent its being tampered with.

Method of Measurement.—In electric lighting stations, to indicate the amount of current flowing in the circuit, an ammeter is inserted in series in one of the mains and with the lamps, and therefore the whole of the current passing to the lamps passes through the ammeter, and is measured by the latter. A voltmeter is connected across the two main leads, or in shunt with the dynamo, and measures the difference of potential between the two mains in volts. By taking simultaneous readings of the voltmeter and ammeter, the energy being expended in the circuit can be ascertained. For example, suppose the voltmeter to indicate 100 volts, and the ammeter 100 amperes, then (by the equation $EC=W$), $100\times100=10{,}000$ watts are being expended in the circuit. The output of dynamos is usually expressed in watts, as this indicates the actual electrical power given by the machine, irrespective of the strength of the current, or its pressure, which may be varied to any extent so long as their product remains constant.

Method of Recoil.—A method of measuring a discharge by the amount of recoil of the needle's swing in a ballistic galvanometer.

Method of Slow Discharge.—A method of testing the insulation of line by measuring the rate of leakage from the conductor when left insulated.

Methven Screen.—An upright metal screen pierced with a narrow rectangular aperture, and fixed opposite the flame of an Argand burner, for the purpose of establishing a standard of illuminating power.

Metric System.—The system of measurement, first adopted in France, now universally employed in scientific practice, in which the *meter* is the fundamental unit of length; all the units, both fundamental and derived, are divided decimally, and higher units are formed in multiples of *ten.*

Mho.—A unit of electrical conductance, being the reciprocal of the *ohm,* the unit of resistance.

Mho Box.—A box for measuring conductance in *mhos.*

Mhometer.—An instrument for measuring electrical conductance in terms of the *mho.*

Mica.—A mineral substance, distinguished by nearly perfect cleavage, largely used for insulating purposes because of its excellent properties of insulation and durability.

Mica is capable of being split into elastic plates of extreme thinness. It is either colorless or presents some shade of light brown, gray, smoky brown, black, and occasionally green or violet. It is generally more or less transparent.

Mica possesses an electrical resistance of 84,000,000,000,000 ohms per cubic centimeter and is an ideal insulator, except for the fact that it frequently contains impurities that reduce its dielectric efficiency, and also when used as insulation for spark plugs, owing to its laminated structure, oil and gas may be forced by the pressure of

compression between the sheets composing the insulating sheath, thus, in time, producing short-circuiting of the current.

Micanite.—An insulating material consisting of small pieces of mica built up into sheet form by shellac cement under pressure. It is an excellent insulator, and is employed in making induction coils.

Micro.—A prefix to a unit of measurement to denote one-millionth part of that unit.

Micro-ampere.—A unit of current equal to one-millionth of an ampere.

Micro-coulomb.—A unit of electric quantity equal to one-millionth of a coulomb.

Micro-farad.—A unit of electric capacity equal to one-millionth of a farad.

Micro-gilbert.—A unit of magneto-motive force equal to one-millionth of a gilbert.

Micro Glow Lamp.—A name for a diminutive *incandescent lamp.*

Micro-graphophone.—A multiple non-metallic diaphragm phonograph in which separate diaphragms act upon a single diaphragm in recording the speech, so that more intense vibrations may be produced in reproducing sound.

Microhm.—A unit of resistance equal to one-millionth of an ohm.

Micrometer.—An instrument for measuring minute distances and angles, consisting usually of a glass slip ruled with fine lines and controlled by an accurate screw of fine pitch. For instance, one twentieth of a revolution of a screw of 50 threads to the inch, gives $\frac{1}{50 \times 20}$ or advances the point $\frac{1}{1000}$ inch.

Micrometer Eye Piece.—An eye piece of an optical instrument provided with a micrometer in front of the object glass.

Micrometer Gauge.—An accurate form of wire gauge consisting of a yoke of tempered steel in one side of which is mounted a graduated thumbscrew; the screw is turned against the wire to be measured till a light contact is made between the screw and the opposite side of the yoke.

Micrometer Microscope.—A microscope having a micrometer eyepiece for determining its magnifying power.

Micron.—A unit of length equal to one-millionth of a meter or one-thousandth of a millimeter.

Microphone. — An electrical device for intensifying sound by the use of a loose carbon contact between two conductors in the circuit of a telephone receiver. Modern carbon telephone transmitters embody this principle, and are essentially microphones.

One form of microphone consists of a pencil of battery carbon, sharpened at both ends, and loosely attached in sockets hollowed in two carbon blocks, which form the electrodes of the instrument. The whole, mounted on a resonant sounding board, is extremely sensitive to minute sounds, being literally, as its name indicates, to small sounds what the microscope is to small objects.

Microphone Induction Coil.—An induction coil used with a *telephone transmitter.*

Microphone Relay.—A microphone combined with a telephone so that a message transmitted over the telephone is repeated by the microphone over another line

Microphonic Contact.—A loose contact, as of carbon between two conductors in an electric circuit, in order to magnify sound, such as the contact of granular carbon in a telephone transmitter.

Microscope.—An optical instrument provided with a lens or a combination of lenses, for examining objects too small to be observed with the naked eye.

Microscopic.—So small as to be seen only with the microscope.

Micro-seismograph.—A sensitive electrical instrument for indicating and recording slight earthquake vibrations.

Micro-tasimeter.—An instrument for measuring extremely slight temperature or moisture changes, by the varying pressure exerted upon a carbon button.

Micro-telephone.—A compact form of telephone desk set. This is so constructed that the transmitter and receiver are both mounted upon one handle, in order to be conveniently used, in whatever position the operator may be. It is also far more portable than the familiar standard desk set, and, for this reason, is used extensively for army telephones, in factories, and in testing outfits.

Micro-volt.—A unit of electromotive force equal to one-millionth of a volt.

Migration of Ions.—The movement of the ions toward their respective electrodes, which takes place in a solution during the process of *electrolysis*.

Migration Velocities of Ions.—The unequal velocities with which ions travel in a liquid undergoing electrolysis.

Mil.—A unit of length equal to one-thousandth part of an inch, used especially in the measurement of diameters of *wires*.

Mild Steel.—A class of steel of great tenacity and ductility which is an alloy of iron with a very small percentage of carbon; it has a crystalline structure and is weldable but cannot be hardened. Mild steel is used for the cores of electromagnets.

Mile Ohm.—In telephone and telegraph practice, the weight of a piece of wire one mile long having a resistance of one ohm. The poorer the conductor the greater the weight of the mile ohm, hence the *weight* per mile-ohm is a convenient way of expressing the electric conductivity of wires.

To ascertain the mileage resistance of any wire, divide the *weight per mile ohm*, by the *weight of the wire per mile*. The weights per mile ohm of different grades of line wire are as follows. B. B. wire, about 5700 lbs.; E. B B. wire, about 5000 lbs.; steel wire, about 6500 lbs.

The approximate weights per mile of various sizes of galvanized telegraph wire are as follows:

No. (Trenton gauge)	4	5	6	7	8
Lbs , per mile	720	610	525	450	375
No. (Trenton gauge)	9	10	11	12	13
Lbs., per mile	310	250	200	160	125

Mil-foot.—A standard of resistance in wire: it is the resistance of one foot of wire having a diameter of one mil.

Mili-ammeter.—An ammeter having its scale graduated to read thousandths of an ampere; also spelled milli-ammeter.

Milli.—A prefix to a unit of measurement denoting one-thousandth part of that unit.

Milli-ammeter.—An instrument for measuring the strength of an electric current in terms of milli-amperes.

Milli-ampere.—A unit of electric current equal to one-thousandth of an ampere.

Milli-calorie.—A heat unit equal to one-thousandth of a greater calorie; the *lesser calorie*.

Milli-henry.—The thousandth part of a henry.

Millimeter.—A unit of length in the metric system of weights and measures equal to one-thousandth of a meter, or .03937 inch.

Milli-oersted.—One-thousandth of an oersted.

Milli-volt.—A unit of electromotive force equal to one-thousandth of a volt.

Milli-voltmeter.—A voltmeter for measuring small differences of potential in terms of the thousandth part of a volt.

Mill Power.—A term used to designate a unit of water power larger than horse-power. Its value varies in different localities.

Mine Exploder.—A magneto suitable for exploding a blast.

Mine Locomotive.—A form of electric locomotive employed in mines. It consists usually of a four wheeled truck carrying a motor geared to one axle. It is provided with a seat for the driver, a headlight, a short trolley pole and a controller. The current is taken from an overhead copper wire with return by the rails.

Mineral.—1. An inorganic substance, generally solid, having a definite molecular structure and chemical composition, and further distinguishing physical characteristics, such as crystallization, cleavage, hardness, fracture, etc., any inorganic body forming part of the earth's crust; anything dug out from the earth.

2. Having the character of a mineral, or obtained from a mineral source.

Mineral Oil.—Oil of mineral origin is either petroleum, or some of its distillates. It comes from oil wells, or oil bearing shale. Its widest use is for illuminating purposes, but it is also extensively employed for lubrication of machinery in situations where it is impracticable to use animal oils, such as sperm, or lard.

Miners' Dial.—A compass provided with a magnetic needle, a horizontal dial graduated to 360°, and sights through which stations may be observed in order to as-

certain the direction of lines. The instrument is used for underground surveying, hence its name.

Miners' Inch.—In mining laws of various regions, the quantity of water that will pass an opening of one square inch in twenty four hours, under a head of six inches.

Miniature Lamp.—1. Small incandescent lamps are employed as signals in central energy telephone switchboards. They are usually of one-third candle power, tubular in form, mounted in opaque tubes provided with glass jewels. The terminals of the filament are joined to metal contact pieces on opposite sides of the bulb.

2. Diminutive forms of incandescent lamps are also designed for adaptation to delicate surgical operations.

Minium.—The red oxide of lead commonly used to paste on the positive pasted plates of a storage cell. It is a rare mineral, occurring as a pulverulent decomposition product of other lead ores. Minium has been found in small quantities in many localities where galena or cerussite occurs.

Minotto's Cell.—A modification of Daniell's cell, dispensing with the porous cup and adopting the gravity principle, in which a copper disc rests on the bottom of the jar, above which is a thick layer of crystals of copper sulphate, then a mass of moist sawdust upon which rests a zinc block.

Minus Charge.—A negative electric charge which is indicated by the minus sign (—). It is the kind of electrification that is developed on resinous substances by rubbing with flannel or fur.

Miophene.—In electro-therapeutics, an apparatus for examining the muscles.

Mirror Galvanometer.—A very delicate galvanometer in which a small mirror is attached to the needle, so that a beam of light is reflected upon a scale, and the slightest motion of the needle is magnified; a reflecting galvanometer.

Sir William Thomson's mirror galvanometer has a body consisting of a bobbin on which is wound a coil. The magnet consists of one or more small pieces of steel watch spring attached to the back of a light concave silvered glass mirror weighing about three grains. The mirror is suspended by a cocoon silk fibre within the coil. A curved magnet is provided which counteracts the magnetism of the earth. Opposite the galvanometer is placed the scale, and a beam of light from a lamp passes through a narrow aperture under the scale and falls on the mirror from which it is reflected upon the scale.

Mirror Magnetometer.—A magnetometer having a reflecting mirror and scale, for making delicate measurements of the earth's magnetic elements.

Mirror Receiver.—A mirror galvanometer for receiving signals over submarine cables.

Misfiring.—A failure to ignite on the part of the explosive mixture within the cylinder of an internal combustion engine, usually caused by a weak battery, partial or entire breaks in the primary circuit, or almost any defect in the ignition system.

Mixed Circuit.—1. A telephone circuit combining both metallic and ground return.

2. A circuit in a system of mixed distribution.

Mixed Circuit Switchboard.—A telephone switchboard containing both metallic and earth return circuits.

Mixed Distribution.—Electrical distribution combining the series with the parallel systems; a distribution employing multiple series connection.

Mixing Key.—A key employed for producing the charge in the mixed charge capacity test of a submarine cable.

Mixture.—A general term for the fuel of an internal combustion engine consisting of a compound of air with a hydrocarbon. A mixture is termed "rich" or "fat," when it contains an excess of gasoline, and "poor" or "lean" when it does not contain sufficient gasoline.

mm.—Abbreviation for millimeter.

M. M. F.—Abbreviation for magneto motive force.

Mobility of Ions.—In electrolysis, the electrolyte is regarded as composed of positive ions called cations and negative ions called anions. These ions move along the lines of electric force which pass through the electrolyte from one electrode to the other. The *mobility* or *migration velocity* is the speed with which the ions move when acted upon by unit force.

Moderate Speed Generator.—A dynamo intended to operate at a moderate speed.

Modulus.—A term used in mathematics, mechanics and physics, being "a number or quantity that measures a force or effect," hence, the primary signification of modulus is a measure; the modulus of a machine means the same as the efficiency of it. The modulus of a machine is a formula (or measure) expressing the work a given machine can perform under the condition under which it has been constructed; the words mode, model, mould are kindred terms, all formed from the same root word and meaning somewhat the same. Plural, moduli.

Moist Cell.—A type of cell usually known as the "dry" cell, in which, instead of a liquid electrolyte, the materials are made up into a damp paste.

Moist Electrode.—In electro-therapeutics, an electrode which is moistened before application.

Moisture in Steam.—It is important to ascertain the quality of the steam in making boiler and engine tests. When the condenser test cannot be made, the steam may be tested by a calorimeter as follows: A perforated ½ inch pipe is inserted into the main steam pipe near the boiler. Steam is taken through this pipe and led through a hose thoroughly felted, to a barrel holding 400 lbs. of water, set upon a platform scale, and provided with a valve for allowing the water to flow to waste, and with a small propeller for stirring the water. After weighing barrel and water, and noting temperature of the latter, steam is turned on and the hose suddenly thrust into the water, and propeller operated until temperature is increased to, say, 110°. The hose is quickly withdrawn, temperature noted and weight again taken.

The moisture in the steam may then be calculated as follows:

$$Q = \frac{1}{H-T}\left[\frac{W}{w}(h_1-h)-(T-h_1)\right]$$

in which

Q=quality of the steam, saturated steam being unity.

H=total heat of one lb. of steam at observed pressure.

T=total heat of one lb. of water at temperature of steam of the observed pressure.

h=total heat of one lb. of condensing water, original.

h_1=total heat of one lb. of condensing water, final.

W=Weight of condensing water, corrected for apparatus.

w=weight of steam condensed.

Percentage of moisture=1–Q.

Mol.—A term sometimes used for gram-molecule, the number of grams of a substance equal to its molecular weight.

Molar Attraction.—The universal attraction which all bodies exert upon each other.

Molar Vibration of Telephone Diaphragm.—The vibration of the mass of the diaphragm in a telephone transmitter as distinguished from its molecular vibration.

Molecular Accommodation.—The action of the molecules of a mass of iron when subjected to a magnetizing force, such that they seem to accommodate themselves to the force, with the result that the iron, as a whole, becomes a magnet.

Molecular Agitation.—A jarring force applied to iron, in order to so agitate its particles as to reduce the tendency to magnetic hysteresis.

Molecular Attraction.—The attraction exerted by one molecule upon another, as apart from the attraction of gravitation. The cohesion of bodies and chemical affinities are examples of this force, the tensile strength of a bar of steel being due to the attraction which its molecules have for each other.

Molecular Bombardment.—In a Crookes tube in which exhaustion has been carried to a high degree, the violent projection of electrified molecules from the surface of the cathode, producing luminous effects.

Molecular Chains.—The chains in which, according to Grotthuss's hypothesis, the molecules of an electrolyte arrange themselves in the process of electrolysis.

Molecular Conductivity.—The conducting power of a gram-molecule of electrolyte through an interval of one centimeter between electrodes.

Molecular Configuration.—The irregular arrangement of the molecules in a mass of iron before they are acted upon by a magnetizing force.

Molecular Decomposition or Dissociation.—The breaking up of a molecule of matter into its constituent atoms.

Molecular Force.—A force exerted between molecules but only at infinitely small distances.

Molecular Heat.—The number of gram-calories required to raise the temperature of a gram molecule of any substance 1° Centigrade.

Molecular Kinetics.—The study of the forces that produce motion in molecules of matter.

Molecular Magnetic Rotation.—All liquids have the power of rotating a ray of polarized light when placed between the poles of a powerful electromagnet. The rotations of the substance and of the water are observed in equal tubes, and the densities of the substance and of the water are accurately determined from the formula:

$$\frac{rM}{d} + \frac{r'M'}{d'}$$

in which, r and r' are the observed rotations of the substance and water, respectively, M and M' their molecular weights, and d and d' their densities.

Molecular Magnetism.—The magnetism which is assumed to exist inherently in the molecules of a magnetizable substance, according to the physical theory of magnetism.

Molecular Magnetization.—The magnetization of molecules considered as magnets.

Molecular Magnetomotive Forces.—The magnetomotive forces existing in the molecules of a magnetizable substance in which the molecules themselves are regarded as perfect magnets.

Molecular Magnets.—The molecules of a substance considered as original magnets.

Molecular Oscillations.—The constant motion possessed by molecules of matter.

Molecular Range.—The range through which attraction or repulsion is exerted between molecules of matter.

Molecular Repulsion.—The repulsion exerted by one molecule upon another by the force of molecular encounters.

Molecular Resistance.—The resistance offered by a gram molecule of electrolyte through a distance of one centimeter between electrodes.

Molecular Shadow.—In a high vacuum tube, a well defined shadow cast by any object interposed in front of the cathode in the path of the discharge of electrified molecules; *an electric shadow.*

Molecular Streams.—Streams of electrified molecules projected in parallel paths from the cathode of a high vacuum tube; *negative rays.*

Molecular Transfer of Heat.—The conduction, or transference, of heat from molecule to molecule in a solid body.

Molecular Vibration.—Vibrations set up among the molecules of the diaphragm of a telephone transmitter by the influence of the magnet, as distinguished from mass or molar vibration.

Molecule.—The smallest particle in which a substance can exist in the free or uncombined state, or the least part into which a compound can be subdivided and yet retain its characteristic properties. The molecule of any compound must contain at least two atoms, and generally consists of many more.

Molten Platinum Lamp.—A name sometimes given the lamp by which the unit of light intensity called the *violle* is established, the light being emitted in a perpendicular direction by one square centimeter of platinum at the temperature at which it melts.

Moment.—The magnitude of a force tending to produce rotation about a point multiplied by the perpendicular distance from the point to the line of the force.

Momentary Current.—A current that flows only for a brief time.

Moment of Couple.—The product of two component forces which imparts a twist or turning movement to a body capable of rotation. Applied to an electric motor, the moment of couple or the *torque* is the twisting force which is exerted upon the armature by the passage of an electric current through it. The two components of the torque are (a) the *pull* measured in pounds, and (b) the *distance* in feet from the center of the shaft to the point where the pull is applied.

Since a couple has no single resultant, no single force can balance a couple. To prevent the rotation of a body acted on by a couple the application of two other forces is required, forming a second couple.

Moment of Inertia.—In mechanics, said of a rotating body; the *sum* of the products of the mass of each particle of matter of the body, into *the square of its distance* from the axis of rotation. Called also *moment of rotation* and *moment of the mass.* In other words, if a particle of mass, m, be revolving in a circle of radius r, the quantity mr^2 is called its moment of inertia.

Moment of Magnet.—The product of the strength of one of the poles of a uniform

bar magnet by the distance between the two poles.

Momentum.—The quantity of motion of a moving body, obtained by multiplying the mass of the body by its velocity. Momentum might also be defined as numerically equivalent to the number of pounds of force that will stop a moving body in one second or the number of pounds of force which, acting during one second, will give it a given velocity.

Monochromatic Photometry.—The measurement of homogeneous or monochromatic light; that is, pure light containing but one color.

Monocular.—An eye piece of an optical instrument designed for adjustment to one eye only.

Monocyclic Alternator.—A special type of generator employed in the monocyclic system, having a main single phase winding and an auxiliary or teaser winding connected to the central point of the main winding, in quadrature with it. Two wires leading from the single phase winding supply current to the lighting system, while a third wire from the teaser extends to polyphase motor installations.

Monocyclic Armature.—The armature of a monocyclic alternator wound with an ordinary coil winding in slots, and an auxiliary or "teaser" winding in smaller slots midway between those of the main winding.

Monocyclic Circuit.—The circuit connected with a monocyclic generator.

Monocyclic Motor.—A variety of induction motor employed in the monocyclic system of alternating current distribution.

Monocyclic System.—An alternating current system which is essentially single phase provided with a so called *teaser winding* displaced 90° from the main winding on the alternator, the two windings having the same relative position as the windings of a two phase alternator. But the *teaser* has only one quarter as many turns as the main winding, serving to produce an E. M. F. slightly out of phase with the main E. M. F., thereby providing a rotating field for motors.

In the monocyclic system, three wires are used, but the main or energy current is conveyed by two of the wires, while the third one serves as an auxiliary and is necessary for starting the motor. The motors are of the class called "induction motors" from the fact that the current in the armature or revolving part is induced by an alternating current in a stationary coil outside of the armature and at an angle to the field, instead of being conducted into the armature through sliding contacts as in the more familiar direct current motor.

Motors constructed upon this principle have great starting power, and are able to stand temporary overloads without damage. They can be made smaller than the direct current type, are cylindrical in shape, and adapted to be put in any position.

The monocyclic in its broadest sense is a combination of the single phase and three phase systems. Three phase currents are produced from single phase currents by means of a specially wound armature which may be operated as a motor-generator at the point where energy for motors is to be distributed, or the main generator may be provided with a special armature arranged to produce the necessary difference of phase between the ordinary two-wire circuit and a third wire.

Monophase.—Single phase· applied to a single pressure wave supplied by a simple alternator to a two wire circuit.

Monophote Arc Light.—A lamp operated singly upon its own circuit, and having the whole current pass through its arc regulating mechanism.

Moonlight Schedule.—In electric lighting, a table showing the hours of moonrise and moonset with indications of the moon's phases, and instructions as to when lights should be turned on and extinguished with reference to the light given by the moon.

Moore Light.—A system of electric lighting in which long glass tubes, one and three-quarters inches in diameter, containing rarefied non-metallic gases, are made luminous by the passage of an alternating electric current. The color of the light depends upon the gas admitted to the tube. When fed with pure nitrogen the color resembles closely that of diffused daylight, when air is admitted the color is orange-pink. The quality of the light is very mild and agreeable to the eyes. This light was established in commercial service in 1903.

Mooring Chain.—In submarine cable work, a chain for mooring a buoy.

Mop.—In electroplating, an implement for polishing plated surfaces.

Mordey Alternator.—An alternator designed by W. M. Mordey, an English engineer; its armature is fixed, the field magnet being rotated, and the lines of force in the various fields projected through the armature coils are all in one direction, the pole pieces on one side of the armature coils being all of north polarity, and those on the other side of south polarity.

Mordey Effect.—A phenomenon, first observed by Mordey, of decreasing hysteresis in the armature, when the dynamo is at full load.

Morin's Laws of Friction.—1. *The friction between two bodies is directly proportional to the pressure;* that is, *the coefficient is constant for all pressures.*

2. *The coefficient and amount of friction, pressure being the same, is independent of the areas in contact.*

3. *The coefficient of friction is independent of velocity, although static friction (friction at rest) is greater than the friction of motion.*

Denton says: "I do not believe there is a particle of proof in any investigation of friction ever made, that Morin's laws do not hold for ordinary practical oil cups or restricted rates of feed."

Morse Alphabet or Code.—The Morse telegraphic alphabet.

Morse Embosser.—The Morse recorder.

Morse Ink Writer, or Inker.—A form of Morse recorder in which the attraction of the armature raises an inked wheel against the paper ribbon, and thereby prints upon it the dots and dashes of the message.

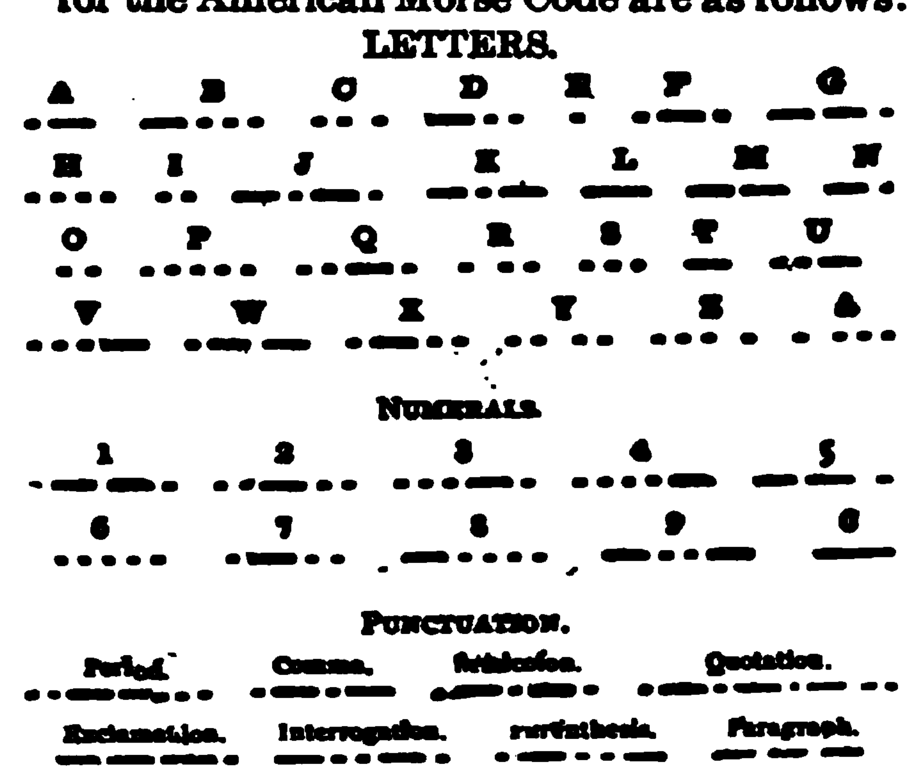
Morse Recorder, or Register.—An early form of telegraphic receiving instrument, consisting essentially of an electromagnet moving an armature which is arranged to emboss the dots and dashes of the message upon a paper ribbon drawn through the instrument by clockwork; it is now wholly supplanted in the U. S. by the *sounder*.

Morse, Samuel Finley Breese.—Born 1791, died 1872. An American inventor, famous for his invention of the electric telegraph (1835). He began life as an artist; in 1832 he became interested in certain experiments which were going on in Paris for the transmission of electricity over long distances, and for the next three years he devoted himself to the problem of sending messages by that means. His first model was completed in 1835 and in 1837 he first put his system into operation. After several years of discouragement, because of lack of recognition, he was awarded an appropriation of $30,000 by Congress for an experimental line from Washington to Baltimore. After this, success was rapid and before his death his system had been adopted by the leading countries of the world. In 1842, he laid, in New York Harbor, the first submarine cable ever successfully attempted. He received very high honors from the heads of European powers and his own government as a great benefactor of civilization.

Morse System of Telegraphy.—A system of electric transmission of signals developed by S. F. B. Morse. As at present employed in the U. S. the system requires three instruments, the *key*, the *relay* and the *sounder*; by making and breaking the circuit with the key the dots and dashes, or "clicks", of the Morse alphabet are transmitted along the line.

Morse Tapper.—A sounder invented by Morse which produces a tapping sound by the movements of a lever attached to the armature of an electromagnet.

Morse Telegraphic Alphabet.—The system of dots and dashes devised by Morse as a code for telegraphic signaling. The American Morse code, used in the U. S. and Canada, is the original Morse alphabet; the International Morse code, employed abroad has certain modifications and differs considerably from the American code, the signals for some of the letters of the latter depending on the length of the spacings between the dots and dashes. The signals for the American Morse Code are as follows:



Mortar.—A cementing material consisting of a mixture of lime and sand with water, used to bind together bricks or stones into structures. It "sets" or hardens in the air, and not under water, its setting consisting in the changing of the hydrate of lime into the carbonate by the absorption of carbonic acid from the atmosphere. This naturally is a slow process. Hardening also depends upon the crystallization of the mortar, and is greatly facilitated by using uniform sand of sharp and angular nature, as lake or river sand.

The best known and most reliable mortar used in building construction is composed of three parts of clean *sharp sand*, free from earthy matter, and one part of *freshly slaked lime*.

Motive Power.—Any agent such as steam, water or electricity, for imparting power to

drive machinery, together with the appliances for transmitting the power, such as shafting, pulleys, belting, etc.

Motor.—1. An electric motor is a machine for transforming electrical into mechanical power. There are many types of motors designed to meet varying conditions, such as *single phase, polyphase, a. c.* and *d. c.*, depending upon the kind of current supplied to them, and others adapted to the kind of work to be done by them. Almost any generator will operate as a motor when current is supplied to it, but certain types of motors are not suitable to act as generators, not being the reverse of any dynamo type.

2. Internal combustion or electric engines, used to propel vehicles on ordinary roads (motor cars), or internal combustion engines employed for propulsion of small craft, or for working single vehicles on railways.

Motor Armature.—The armature of an electric motor.

Motor Boat.—A small craft propelled by a motor. Sometimes, though incorrectly, called *power boat.*

Motor Car.—An automobile; a vehicle for use on ordinary roads propelled by a prime mover.

Motor Car, Electric.—An automobile propelled by electricity.

Motor Circuit.—The circuit of an electric motor.

Motor Controlling Rheostat.—A rheostat offering high electric resistance, employed for controlling the electromotive force applied to a motor.

Motor Converter.—A combination of an induction motor with a synchronous converter, the secondary of the former feeding the armature of the latter with current at some frequency other than the impressed frequency; a *cascade converter.*

Motor Cut Out.—A cut out for removing an electric motor from its circuit.

Motor Cycle.—A bicycle driven by an explosion motor, usually in conjunction with pedaling on the part of the rider in starting.

Motor, Electric.—A machine used to convert electrical energy into mechanical work. Motors are, however, divided into two general classes: (1) Those for use with continuous currents, (2) those for use with alternating currents. Motors are also classified the same as dynamos, as series wound, shunt wound, compound wound, bipolar and multipolar motors.

Two points are vital to the right understanding of the action of electric motors: (1) The propelling drag, (2) the counter electromotive force. The first is that the real driving force which propels the revolving armature is the drag which the magnetic field exerts upon the armature wires through which the current is flowing, the second is that the revolving armature generates a counter electromotive force as its moving wires cut the magnetic lines.

In the dynamo, where energy is being supplied to the the circuit, the electromotive force is in the same direction as the current; while in the motor where work is being done, and energy is leaving the circuit, the electromotive force is in a direction which opposes the current.

Motor Electromotive Force.—The counter electromotive force of a motor.

Motor Generator.—A transforming device consisting of a motor mechanically connected to one or more generators for the purpose of changing direct current of one voltage into direct current of another voltage. A dynamotor that changes from an alternating current to a direct current or vice versa is called a *rotary converter.*

Motor Generator Set.—A combination of motor and generator by means of which a current of one voltage may be used to drive a motor which in turn operates a dynamo for generating a lower voltage. In this way current may be taken from lighting mains and changed to a lower voltage suitable for charging a storage battery.

Motoring at Brushes.—The sparking or flashing of the brushes on the commutator of a motor armature.

Motorman.—The man who operates the controller of a trolley car, and drives the car.

Motor Meter.—A form of electric meter, consisting essentially of a small electric motor, designed to give its readings direct in watt hours.

Motor Shaft.—The main or crank shaft of a motor.

Motor Slip.—In an induction motor, a difference in rate of rotation between the rotating field and the rotor, due to resistance opposed to the rotor current.

Motor Standards.—The supports upon which an electric motor rests.

Motor Starter.—A rheostat, sometimes called a *starting box*, inserted in the armature circuit of a shunt motor to prevent an excessive rush of current before the motor attains its speed. As the speed of the motor increases the resistance is gradually cut out.

Motor Starting Box.—A box in which the starting rheostat is placed.

Motor Starting Rheostat.—A resistance provided to prevent too great a rush of current into a motor when starting; a motor starter.

Motor Suspension.—In electric traction, the method of suspending a motor from the truck of an electric car. There are three principal types of suspension, the *nose* suspension, the *side bar* suspension, and the *cradle* suspension. Other methods are modifications of these three. In the nose suspension, one end of the motor is carried by a lug or suspension bar while the other end is supported by the axle. In the side bar suspension the motor is attached to the axle as usual, and the rest of its weight is borne by two parallel side bars resting upon springs. The third type consists of a cradle resting in front upon a cross beam, which is supported by the side frames of the truck and at the back, being carried on the arm that carries the axle bearing. This cradle supports the motor.

Motor Switch.—A switch controlling a motor.

Motor Telegraph Printing System.—A system of printing telegraphy employing a pair of synchronous motors, one at each end of the line.

Motor Torque.—The pull or turning moment which produces the rotation in a motor.

Motor Transformer.—A term sometimes applied to a dynamotor. It consists of a motor and generator built as one machine having only one field magnet and one armature but with two distinct windings, one of many turns of fine wire connected to a commutator at one end, and the other of few turns of coarse wire connected to a commutator at the opposite end. Sometimes the dynamotor has two armatures. It is used to change voltage from higher to lower pressure.

Motor Truck.—A car truck equipped with an electric motor.

Moulded Carbons.—Artificial carbons for arc lighting, prepared by mixing ground graphite and pure carbon powder, forming a paste by the addition of some adhesive substance, and then moulding or squeezing into shape.

Moulded Filaments.—Carbon filaments for incandescent lamps in which the material is first made homogeneous under pressure.

Moulded Mica.—An insulating material made up of pulverized mica mixed with a suitable cement, and moulded into shape under pressure.

Mouldings, Electric.—Wooden mouldings suitably grooved on the under side, for supporting and concealing electrical conductors in interior wiring.

Moulding Wiring.—A method of wiring a building by running the conductors along the walls and ceilings under suitable wooden mouldings.

Mounted Filament.—An incandescent lamp filament fused upon a platinum support, and ready for the glass bulb.

Mounting of Filament.—The process of fixing an incandescent lamp filament upon its platinum support preparatory to sealing it into the glass bulb.

Mountings.—That by which anything is prepared for use; equipment; as, the mountings of a steam boiler, meaning the safety valves, water gauges, etc.

Mouse Mill Machine.—A form of electric influence machine invented by Lord Kelvin.

Mouth Piece.—1. An opening, suitable for receiving the sound waves emitted by the voice, as in telephone transmitters, phonographs, and similar instruments.

2. That part of a boiler furnace through which the fuel is introduced and often some air. The lower side of the mouth piece is the *dead plate*.

Movable Secondary.—In an induction coil, a secondary that is capable of being moved.

Moving Coil Galvanometer.—The d'Arsonval type of galvanometer, one of the two principal classes of galvanometer. A small coil is suspended by a fine wire between the poles of a magnet, with its axis at right angles with the lines of the field. Current enters the coil by its suspension and leaves it by a flexible wire below it.

Moving Needle Galvanometer.—One of the two principal classes of galvanometers. A magnetized needle is suspended so as to move freely in a horizontal plane. Near the needle, and often surrounding it, is a coil of wire with its axis at right angles to the normal direction of the needle. When a current flows through the coil the needle tends to turn.

m. s.—Abbreviation for meter per second.

m. s. Current.—A contraction for mean square current.

Multi-cellular Voltmeter.—A form of electrostatic voltmeter for measuring low potentials, employing a number of plates or vanes, each moving between a pair of fixed conductors.

Multi-circuit Arc Dynamo.—An arc light dynamo having a number of circuits wound upon its armature, in order to prevent too high potential in any one circuit.

Multi-coil Armature Winding of Alternator.—A method of winding in which more than one coil on the armature is provided for each field magnet pole.

Multi-conductor Cable.—A cable composed of several electric conductors.

Multi-cylinder.—Having many similar cylinders. An automobile engine is said to be multi-cylinder as it possesses two or more cylinders, the object being to insure even turning and less vibration.

Multi-duct Conduit.—A conduit containing several ducts or longitudinal passages for the introduction of electric wires.

Multi-filament Lamps.—In large incandescent lamps, such as those of five-hundred candle power, there are frequently a number of filaments joined in parallel. With this method of connection, the lamp is still of service in the event of one filament breaking, the electrical power absorbed being reduced in a corresponding degree.

Multi-gap Lightning Arrester. — A form of arrester in which a number of cylinders are arranged in series so as to break up the arc into several short lengths.

Multi-meter.—A "universal" electrical measuring instrument designed to serve the purposes of a voltmeter, ammeter, ohmmeter, ground detector and Wheatstone bridge. It consists essentially of a combination of a Wheatstone bridge, a battery of twelve silver chloride cells, and an indicating instrument with detachable shunts.

Multi-phase.—A term applied to any alternating current system employing currents of two or more phases, as distinguished form single phase. The term *polyphase* is more commonly employed.

Multi-phase Currents.—Multi-phase currents are two or more separate and distinct currents not differing in any way from the current derived from an ordinary "single phase" alternator. Their peculiarity lies in the fact that they have different strengths at a given instant of time.

In the two-phase system, when one of the currents is at zero value, the other has its maximum value, or the currents are displaced *in phase*, whence the expression two-phase.

If two identical simple alternators have their armature shafts coupled in such a manner, but when a given armature coil on one is directly under a field pole, the corresponding coil on the other is midway between two poles of its field, the two currents generated will differ in phase by a half-alternation, and will be two-phase currents; similarly, three-phase currents could be generated by coupling the armatures of three simple alternators so that the corresponding coils on each are equally "staggered" with respect to each other.

Two-phase and three-phase currents differ in this respect; the two-phase system requires four wires to connect the generators with the motors, and their action is that of two distinct and separate circuits through which are passing simple alternating currents of electricity which act upon the revolving part of the motor like the two cranks on a cross connected engine at right angles to each other, or one 90 degrees in advance of the other.

The three-phase method of employing the alternating current requires only three wires, and for transmitting electrical energy in large amounts long distances for power purposes it is an ideal system.

Multi-phaser.—An alternator producing two or more single phase alternating E. M. Fs. differing from each other in phase; a *polyphase alternator* or *polyphaser.*

Multiple Arc Connection.—A connection in an electric circuit so that the current divides in several paths. Also called *multiple, parallel, branched* or *divided* connection.

Multiple Cable.—A cable composed of several electric conductors.

Multiple Cable Core.—The group of conductors forming the core of a multiple cable.

Multiple Call Box.—An automatic call box designed to send several different calls as required.

Multiple Circuit.—An electric circuit so connected that the current in the circuit divides, a part of the current flowing through each of the two portions of the circuit; usually called a *parallel* circuit.

Multiple Circuit Armature Winding.—When there are as many parallel branches in each winding as there are poles in the field frame, the armature coils are said to be arranged in *parallel grouping* or in *multiple circuit* winding.

Multiple Connection.—A term sometimes used for *parallel* connection. When two portions of an electric circuit are so connected that the current divides, a part flowing through each portion, the circuit is said to be connected in *multiple* or *parallel*. A battery of primary cells is connected in *multiple* or *parallel*, when the positive electrodes of all the cells are connected to one main positive conductor, and all the negative electrodes are connected to one main negative conductor.

Multiple Duct Conduit.—A conduit furnished with numerous ducts, or longitudinal passages for the introduction of electric wires.

Multiple Electric Gas Lighting.—A method of simultaneously igniting a number of gas jets, in which the burners are connected with an induction coil from which a succession of sparks are passed almost instantaneously from jet to jet.

Multiple Electrode Transmitter.—A telephone transmitter, such as the dust or carbon transmitter, employing numerous loose contacts.

Multiple Electrolysis.—Electrolysis accompanied by certain important secondary chemical processes.

Multiple Jack.—In a multiple telephone switchboard, one of a series of spring jacks provided for each section of the board, each series containing as many jacks as there are lines entering the exchange.

Multiple Lightning Flash.—A forked lighting flash appearing as a combination of flashes.

Multiple Pair Brush Rocker or Yoke.—A rocker or yoke carrying several pairs of brushes, so that they may be readily shifted together upon the commutator.

Multiple Parallel Circuit.—A multiple of circuits connected in parallel.

Multiple Quadruplex.—In quadruplex telegraphy, a system of repeating messages from one line to another.

Multiple Running or Working.—The operation of electric generators in parallel or multiple. When generators have equal electromotive forces they may be so connected that the total current delivered by the group equals the sum of the currents delivered by the separate generators.

Multiples.—In a multiple telephone switchboard the springjacks, belonging to the same subscriber, repeated at the various sections of the board.

Multiple Series Connection.—A means of joining up most frequently used in connecting primary cells and storage batteries, in which parallel connected groups are arranged in series.

Multiple Switch.—A switch having contacts for several circuits.

Multiple Switchboard.—A switchboard in any system of electrical service, connected with numerous circuits.

Multiple Tablet Switchboard. — A switchboard having several panels.

Multiple Telegraphic Repeater.—An instrument for re-transmitting a telegram from one circuit to two or more other circuits.

Multiple Telegraphy.—The simultaneous transmission of more than one telegraphic message in one direction over the same wire; *diplex telegraphy.*

Multiple Telephone Receiver.—A receiver designed for use in multiple telephony.

Multiple Telephone Switchboard.—A switchboard designed for use in exchanges in which the number of subscribers is too great to be handled at a simple switchboard. The multiple board is divided into sections, each section containing a spring jack, or terminal, for every line entering the exchange, but having line drops of those subscribers only

whose calls are received at that particular section; thus each operator answers the calls of only a comparatively small group of subscribers.

Multiple Telephony.—The transmission of several telephone messages at one time in the same direction over the same wire.

Multiple Transmission.—The transmission of more than one telegraph or telephone message at the same time in the same direction over the same wire.

Multiple Unit Control.—A system of operating electric trains in which each motor car is equipped with a motor controller and a master controller. The motor controller establishes the proper motor connections by means of the master controller operated by the motorman. The master controller instead of directly making the motor changes, merely actuates the motor controller. When the cars are coupled together they are operated by the master controller on the front car, the other master controllers being locked automatically.

Multiple Unit System of Electric Traction.—In the case of electric trains made up of a number of cars, an arrangement by which each car is equipped with its own motors and controllers, these being operated from the front of the train by a master controller; *multiple unit control.*

Multiple Wheel Printing Telegraph.—A printing telegraph apparatus having several discs or wheels for printing the messages as received.

Multiple Windings.—The winding of an electromagnet or armature employing independent coils, insulated from one another, and separately disposed upon the core.

Multiplex Telegraphy.—A system of telegraphy in which more than two messages can be transmitted in opposite directions over the same wire at the same time.

Multiplex Telephony.—A system of telephony in which more than two messages can be sent in opposite directions over the same wire at the same time.

Multiplier.—1. A resistance winding often located outside the instrument case of a voltmeter by means of which the voltmeter may measure pressures beyond its ordinary range.

2. A device in which an electric conductor is coiled several times around a magnetic needle to show that the deflecting force increases with the number of turns: an early form of galvanometer, sometimes called Schweigger's multiplier.

Multiply.—To repeat a circuit at every section of a multiple telephone switchboard.

Multiplying Power of Shunt.—A quantity by which the current passing through a shunt galvanometer must be multiplied, in order to obtain the value of the full current measured.

Multipolar Armature.—An armature designed to rotate between more than two field magnet poles.

Multipolar Drum Armature Windings.—A method of winding a drum armature intended for use in a multipolar field.

Multipolar Dynamo.—A dynamo provided with four or more field magnet poles.

Multipolar Electric Bath.—In electrotherapeutics, a bath provided with a number of electrodes.

Multipolar Field.—An electromagnet field produced by four or more magnet poles.

Multipolar Field Magnets.—These generally consist of four, six, eight or more poles, arranged in alternate order around the armature. They may be arranged in two classes according as the poles are salient or consequent poles. A type of multipolar field magnet extensively used, consists of a ring of iron, having four pole pieces projecting inwardly, over which the exciting coils are slipped, the ring forming a common yoke for all the poles. As a rule, it is made in two portions, bolted together horisontally, so that the upper portion may be lifted off for examination of the armature.

Multipolar Motor.—A motor provided with four or more field magnet poles.

Multipolar Ring Armature Winding.—A method of winding a ring armature intended for use in a multipolar field.

Multipolar Winding.—A method of winding armatures intended for use in a multipolar field.

Multispeed Motor.—A motor, such as those having two armature windings, which can be driven at any one of two or more different speeds practically independent of the load.

Multistage Centrifugal Pump.—One having numerous impellers or fans arranged

in series, the delivery of one going to the suction of the succeeding one. By these means, it is possible to deliver to as great a height as with a reciprocating pump, retaining the advantages of rotary motion.

Municipal Series Circuit.—A series connected incandescent lamp circuit adapted for lighting city streets.

Municipal System of Incandescent Electric Lighting.—A system of incandescent lighting suitable for city streets, in which the lamps are connected in series to the circuit, each lamp having a separate cut out device.

Muntz Metal.—Named after Muntz of Birmingham, England, its inventor. It consists of 60 per cent copper and 40 per cent zinc; is very ductile, can be forged when hot, and has an ultimate tensile strength of 49000 lbs. per square inch.

Muriatic Acid.—Hydrochloric acid or "spirits of salts."

Muscle Currents.—Electric currents occurring in the muscular tissues.

Muscular Pile.—A voltaic pile once constructed by Matteucci, consisting of muscular tissues cut from animals and laid one upon another in such a way as to generate an electric current sufficient to deflect the needle of a galvanometer.

Mushet Steel.—A self hardening tool steel containing about 8½ to 9 per cent of tungsten, and 1½ to 2 per cent of manganese. It is remarkably hard and tough, being especially suitable for turning chilled rolls. It cannot be worked when cold except by grinding, and should be forged to shape by hammering, care being taken not to break it, reheating the tool several times while it is being dressed, and finally, when to its proper shape, hammering it lightly until the color has faded.

Mushroom Anchor.—A form of anchor without flukes, resembling a mushroom in shape, employed to prevent the dragging of buoys in submarine cable operations.

Mushroom Deposit.—A peculiarly shaped deposit which collects upon the negative carbon of an enclosed arc lamp.

Mutual Action of Magnetic Fields.—Whenever any of the lines of force forming part of two separately generated magnetic fields traverse a common space, there is a decided action between the two sets of lines, the tendency being to so alter their paths that as many lines as possible shall coincide in direction. This mutual action takes place independently of the means by which the fields are generated, whether by currents in two wires or by permanent magnets.

Mutual Flux.—In a transformer, the magnetic flux flowing through both coils, as distinguished from a flux confined to either one of them.

Mutual Inductance.—The coefficient of mutual induction. Two electric circuits may exercise an inductive action upon each other so that an E. M. F. may be induced in one by a change of current in the other. This action is called *mutual induction.* Mutual *inductance* is the coefficient by which the time rate of change of the current in one of the circuits is multiplied to give the E. M. F. induced in the other circuit.

Mutually Induced Currents.—Electric currents which occur as the result of mutual induction.

Mutual Induction.—The mutual interference of two electric or magnetic fields by their proximity without contact.

Myograph.—An instrument for measuring the contractions and relaxations of muscular tissues.

Myria.—A prefix used with a physical unit to designate a unit *ten thousand times as great.*

Myriavolt.—A unit of electromotive force equal to ten thousand volts.

n—1. Symbol for the number of lines of magnetic force in a circuit.

2. Symbol for the frequency, or number of vibrations, of a wave motion per second.

3. A signal in submarine telegraphy to indicate the end of a message and the termination of communication for the moment.

4. Abbreviation for *north*, used to distinguish the north seeking pole of a magnet from the south pole.

ν— The Greek small letter *nu*, the symbol of relutivity or specific magnetic resistance.

Nadir.—That point of the heavens directly opposite the zenith; the point directly under the place where we stand; hence, the lowest point; the place or time of greatest depression.

Nail.—A small pointed piece of metal, usually with a head, to be driven into a board or other piece of timber, and serving to fasten it to another timber, or left projecting; as, from a wall, to hang anything upon. The different sorts of nails are named either from the use to which they are applied, or from their shape, as, shingle, floor, ship carpenters' and horseshoe nails, roseheads, diamonds, etc.

The following table will show the length of the various sizes and the number of nails in a pound, they are rated "3-penny" up to "20-penny." The first column gives the name, the second the length in inches, and the third the number per pound.

TABLE.

3-penny	1 inch	557 nails per lb.
4 "	1¼ "	353 " " "
5 "	1¾ "	232 " " "
6 "	2 "	167 " " "
7 "	2¼ "	141 " " "
8 "	2½ "	101 " " "
10 "	2¾ "	98 " " "
12 "	3 "	54 " " "
20 "	3½ "	34 " " "
Spikes	4 "	16 " " "
"	4½ "	12 " " "
"	5 "	10 " " "
"	6 "	7 " " "
"	7 "	5 " " "

Name Plate.—A metal plate affixed to a dynamo, or other machine, giving the maker's name and details concerning the properties and capacity of the machine.

Naphtha.—A light, volatile, inflammable oil, distilled from bituminous shale and petroleum, used as a solvent in the making of paints, the firing of oil engines, etc. Naphtha is a Greek name applied originally to mineral oils of any description.

Narrow Gauge Motor.—A motor designed for use with narrow gauge electric railways.

Nasal Electrode.—In electro-therapeutics, an electrode designed for the medical treatment of the nose.

Nascent State.—The state in which an atom of matter exists at the moment it is freed from chemical combination, when it possesses extraordinary properties of chemical affinity.

National Electrical Code.—A uniform code of rules first formulated in 1898, based upon the requirements of fire underwriters, in accordance with which all interior electric wiring must be performed in order to secure insurance upon the building wired. The code is annually revised to meet new requirements. Copies of the code may be had by applying to the National Board of Fire Underwriters at Chicago or at the nearest Underwriter's Inspection Bureau.

Native Copper.—Copper which is mined in the metallic state. It occurs in the district of Lake Superior and is highly esteemed on account of its purity, which renders it superior to any other copper for electrical purposes.

Natural Current from Cable Break.—A weak electric current set up at the point where a fault, or break, occurs in a cable.

Natural Draft Transformer.—A self ventilating air cooled transformer in which a natural draft of air is set up by the heating of the coils.

Natural Law.—A law of the natural or material universe, a *physical* law. The law of gravitation is a natural law.

Natural Magnet.—Magnetic oxide of iron or magnetite, a mineral which is attracted by a magnet, and sometimes acts as a magnet and attracts iron; *lodestone*.

Natural Period.—A complete period of vibration, or cycle of periodic change fulfilling without interference its natural course.

Naut.—An abbreviation for a nautical mile.

Nautical Measures.—In cable laying, measures of, or pertaining to, the art of navigation, or to ships; as, *a nautical mile.*

TABLE.

60 geographic, or 69.16 statute miles	= 1 degree	of latitude on a meridian, or of longitude on the equator.
360 degrees..	=	the circumference of the earth.
1.15¼ statute miles	=	1 geographic mile, used to measure distances at sea.
3 geographic miles	=	1 nautical league.

A statuto mile is 5,280 feet. It is the standard of distance adopted by the English for land measurements. A nautical mile or *knot* is 6080 feet or 1.152 statute miles. Some writers contend that the word *knot* should only be used to denote a rate of speed.

Nautical Mile.—A unit of distance at sea, equal to 6080, or 1.152 statute miles; a *knot*, or *naut.*

Nautical Telegraphy.—Telegraphy carried on at sea; *wireless telegraphy.*

Naval Brass.—An alloy consisting of 62% copper, 37% zinc, 1% tin; it does not corrode under the action of sea water and can be forged hot.

N. B. S.—Abbreviation for the New British Standard wire gauge.

Nebulæ.—Cloud like luminous masses in the heavens situated far beyond the solar system. They have been observed through the telescope to consist, in many cases, of clusters of very distant stars.

Needle.—1. The pointer which swings over the dial of an electric or other measuring instrument.

2. A light magnetized steel pointer suspended upon a pivot in a mariner's compass so as to set itself in a north and south position along the earth's magnetic meridian.

3. In dial telegraphy, the indicator which swings to the left or right according to the telegraphic code.

Needle Annunciator.—An annunciator having an index needle for its indications instead of a drop.

Needle Electrode.—In electro-therapeutics, an electrode shaped like a needle, designed for delicate operations.

Needle Instrument.—The instrument employed as receiver in the needle telegraph. It consists, in its simplest form, of a vertical galvanometer in which a magnetic needle is deflected to the right or left over a dial, when a current is sent in one direction or another around a coil surrounding the needle.

Needle Lubricator.—An oil vessel whose cork or plug fits into the passage where lubrication is desired, this plug being traversed by an easy fitting needle which rests upon the shaft. The needle prevents a free flow of oil, but its vibration causes a small steady stream to trickle down it into the journal.

Needle of Oscillation.—A magnetic needle used to measure the intensity of a magnetic field, by a calculation of the number of oscillations performed by it in a given time; an *oscillating needle.*

Needle Points.—1. Points of needles, used to fasten fine cabinet work together as dowels.

2. Needles used as points for compasses, dividers and other mathematical instruments, to avoid tearing holes in the paper. The needles are usually locked in the point by means of a nut and bolt, so as to be easily renewable.

Needle Telegraphy.—A system of telegraphy once widely used in England, but now almost wholly superseded by the Morse system; its operation depended upon the right and left swings of a magnetic needle over the face of a dial according to a code of motions comprising the entire alphabet.

Negative.—1. The opposite to positive.

2. In electrical apparatus, the pole or direction towards which the current is supposed to flow, that pole which wastes away the least in an arc lamp or during electrolytic processes.

Negative Brushes of Dynamo.—The commutator brushes which connect with the negative terminal of a dynamo.

Negative Brushes of Motor.—The commutator brushes which connect with the negative terminal of the generator driving the motor.

Negative Bus Bar.—The bus bar which is connected with the negative terminals of a group of dynamos.

Negative Carbon.—In a continuous current arc lamp, the lower carbon rod to which the current flows across the arc from the upper, or positive carbon.

Negative Charge.—A charge of so called *resinous* electricity, or that developed by rubbing sealing wax, or other resinous materials, with wool or flannel.

Negative Component of Electrolyte.—The electro-negative ion, or one of the particles of a solution which carries a negative charge.

Negative Conductor.—A conductor which leads from the negative terminal of a dynamo, or other source of electricity.

Negative Current.—In needle telegraphy, a current which causes a deflection of the needle to the left.

Negative Direction of Electrical Convection of Heat.—A direction, opposite to that of the electric current, followed by heat in passing through an unequally heated conductor.

Negative Direction of Harmonic Motion.—Simple harmonic motion partaking of a left to right direction.

Negative Electric Fluid.—According to an early theory of electricity, called the double or two fluid theory, that "imponderable" fluid which was supposed to be the cause of negative electricity.

Negative Electricity.—The kind of electricity developed by rubbing sealing wax, or other resinous material, with wool or flannel; *resinous electricity.*

Negative Electrification.—A charge of resinous electricity, or that developed by rubbing sealing wax with flannel; a negative *charge.*

Negative Electrode.—1. In a *primary* cell, the *cathode*, which is the copper, carbon, platinum, etc., electrode, is the *negative electrode*, while the *pole* of this electrode is the *positive pole*, because it is positive in relation to the external circuit.

2. In a *storage* cell, the spongy lead plate, which is the anode during discharge, is called the *negative electrode*, and its pole the *negative pole.*

3. In *electroplating*, the cathode, or the metal plate through which the current leaves the electrolyte.

Negative Electromotive Force.—A term sometimes applied to the *counter electromotive force.* This is an E. M. F. of opposite polarity to the impressed E. M. F. and due to inductance in the circuit.

Negative Element of Primary Cell.—The negative electrode, the one by which the current leaves the cell; the *cathode.*

Negative Feeders.—The conductors leading from negative mains to the negative terminals of a dynamo.

Negative Glow.—In electrical discharges between electrodes in a high vacuum tube, a luminous region seen next to the Crookes' dark space.

Negative Lap.—Paring away the inside or exhaust edges of a slide valve to promote earlier exhaust. This opens communication between the two ends of the cylinder at one portion of the stroke, but the advantages gained in some cases outweigh this defect. Also known as *minus inside lap.*

Negative Lightning.—A term applied to those branches of a flash of lightning which show black in a photographic negative.

Negatively Excited.—Charged with negative electricity, as when a resinous substance is rubbed with flannel.

Negative Phase of Electrotonus.—An effect of reducing the electromotive force in a nerve, produced when a current is passed through the nerve in a direction opposite to that of the nerve current.

Negative Plate of Primary Cell.—The *negative electrode*, being the copper, carbon, platinum, etc., plate.

Negative Plate of Storage Cell.—The plate, composed of pure lead with a spongy surface, from which the current flows towards the positive plate in the process of discharging; it is usually of a grayish color.

Negative Pole.—1. The south seeking pole of a magnet.

2. The terminal of an electric generator, into which the current is assumed to enter as it returns from the external circuit.

3. The pole of an electro-receptive device connected with the negative terminal of a generator.

4. In a primary cell, the pole of the positive plate, being negative to the external circuit.

5. In a storage cell, the terminal of the negative or spongy lead plate.

Negative Potential.—In general, the lower potential which causes lines of force to flow towards it from the higher, or positive potential.

Negative Resistance.—The condition of an electric conductor in which a rise of potential occurs as the current flows through it.

Negative Rotation.—The turning of a rotating body from left to right or in the direction of the movement of the hands of a clock; *clockwise rotation.*

Negative Side of Circuit.—The side of a circuit opposite to the positive side, such that, when a current is considered as flowing in a circle about an observer who has his head in the negative region, the current would appear to flow from his left towards his right, with clockwise rotation.

Negative Spark.—A spark produced by negative electrification.

Negative Terminal.—1. In a primary cell, the terminal of the positive electrode.
2. In a storage cell, the terminal of the negative plate.
3. The negative pole of a generator or electro-receptive device.

Negative Wire.—1. A conductor leading to the negative pole of a generator.
2. A wire having a negative potential.

Nernst Lamp.—An incandescent lamp having for its light giving element, a pencil composed of the refractory oxides of rare earth, termed the "glower", which becomes incandescent upon the passage of an electric current. The glower is a non-conductor when cold, but becomes a conductor when heated. The necessary heat is conveyed to the glower by means of "heaters" consisting of thin porcelain tubes wound with fine platinum wire and coated with a refractory paste. A cut out device opens the circuit through the heater when the glower arrives at the proper temperature, and a steadying resistance called the "ballast" prevents the glower's burning out.

Nernst, Walter.—Born 1864. A German physicist, inventor of the Nernst electric lamp (1898).

Net Efficiency.—The *commercial* or *true* efficiency of a generator. It is the ratio of the output of power to the input of power, and may be calculated by the equation; $\text{efficiency} = \frac{\text{power output}}{\text{power output} + \text{losses}}$. The losses are due to (a) work spent in exciting the magnets, (b) resistance of the armature winding, (c) eddy currents and the varying magnetism of armature core, and (d) mechanical friction.

Netted Globe.—A glass globe for an arc lamp, protected by a wire netting.

Netting, Wire.—A netting of wire used to protect the globes of arc lamps.

Network of Conductors.—A group of interlacing and inter-connected conductors in an electric system.

Network of Currents.—The electric currents flowing through a network of conductors.

Neutral Armature.—The unmagnetized armature of a neutral, or non-polarized telegraph relay; a *non-polarized armature.*

Neutral Bus Bar.—In the three wire system of electrical distribution, a bus bar connected to a point between the two dynamos.

Neutral Currents.—Stray electric currents which traverse the ground, often escaping from electric railway and other electric systems; *earth currents.*

Neutral Feeder.—A feeder connected with the neutral wire in a three wire system.

Neutralize.—To cause a charged body to lose its electrification; *to discharge.*

Neutral Line.—In mechanics, when a beam is subjected to flexure, there is a longitudinal center line which is neither in compression nor extension, and is therefore subject to no straining action. The part where this line cuts any particular section is termed the *neutral axis* of the beam; since also the tensile and compressive forces diminish as the neutral axis is approached, girders and girder like structures are frequently lightened out in their central portions. In a beam of uniform section, the neutral line corresponds with the central line of the cross section. In beams of other sections, it will be the mean of bending sections.

Neutral Line of Commutator.—A line passing through the neutral points of a commutator; the *diameter of commutation.*

Neutral Line or Section of Magnet.—In a bar magnet, the portion of the magnet lying midway between the two poles, a region where there appears to reside no magnetic attraction whatever; the *equator* of the magnet.

Neutral Points of Commutator.—Points at the extremities of the diameter of a dynamo commutator, upon which the brushes must be brought to bear in order to avoid sparking.

Neutral Points of Magnet.—Points upon a magnet within its equator, where there is no polarity or attractive power.

Neutral Points of Thermo-electric Diagram.—The crossing points on a thermo-electric diagram of the lines representing the thermo-electric powers of any two metals.

Neutral Relay.—A telegraph relay in which the armature of the electromagnet is not magnetized; a *non-polarized relay.*

Neutral Salt.—In chemistry, a salt which exhibits neither acid nor alkaline properties.

Neutral Solution.—The solution of a neutral metallic salt in a liquid.

Neutral Wire.—In the three wire system of electrical distribution, a central conductor, usually much smaller than the mains, introduced between the positive and negative mains, and kept at a mean potential between them; the *balance wire.*

Neutral Wire Ammeter.—In the three wire system of electrical distribution, an ammeter in the circuit of the neutral wire to determine, when the system is not "balanced", how much the current in one main exceeds that in the other; the *balance ammeter.*

Neutral Zone of Magnet.—The neutral line or section of a bar magnet at its middle or equator, where no magnetic attraction exists.

New Ohm.—A term sometimes applied to the *international* ohm. It is the unit of electric resistance equal to the resistance offered to an unvarying current by a column of mercury at the temperature of melting ice and having a mass of 14.4521 grams, the mercury column having a constant cross sectional area and a length of 106.3 centimeters.

Newton, Sir Isaac.—Born 1642, died 1727. An English mathematician and physicist, famous for his discovery of the universal law of gravitation. He also discovered the binomial theorem, differential and integral calculus, and first computed the area of the hyperbola. He invented a reflecting telescope in 1668. He completed his famous work "Principia" in 1687, embodying his views upon the attraction of gravitation. After this he took active part in public affairs, receiving many distinctions and honors, and at his death was buried in Westminster Abbey.

Newton's Laws of Motion.—1. If a body be at rest, it will remain at rest; or if in motion, it will move uniformly in a straight line until acted upon by some force.

2. If a body be acted upon by several forces, it will obey each as though the others were non-existent, and this, whether the body be at rest or in motion.

3. If a force act to change the state of a body with respect to rest or motion, the body will offer a resistance equal and directly opposed to the force. In other words, every action is opposed by an equal and opposite reaction.

Nib.—A deposit which forms on the negative carbon when an arc is maintained between two parallel carbons.

Nickel.—A hard white metal capable of a high polish. Its specific gravity is 8.9, and it melts at about the same temperature as iron. It is magnetic but is not easily oxidized, hence its use in *nickel plating.* An addition of 5 per cent of nickel increases the tensile strength of steel one-half; the metal is used in nickel plating, as mentioned above, and alloyed in equal proportions of copper and zinc (⅓ of each) it constitutes German silver, much employed for mathematical and drawing instruments, and for resistance wires.

Nickel Alloy.—Any alloy containing nickel; especially, a metal of German origin, from which tubes are made for gas engine igniters.

Nickel Bath.—A bath for nickel plating, in which the solution is prepared from nickel salts, or other double sulphate of nickel and ammonia.

Nickel Facing of Electrotype.—A layer of nickel sometimes deposited upon the face of an electrotype to increase its durability.

Nickel Filings.—In wireless telegraphy, filings of nickel used in connection with silver filings in the early form of Marconi coherer.

Nickeline.—A nickel alloy specially prepared for use in electrical instruments, resistances, etc.

Nickel Iron Cell.—A storage battery cell devised by Edison which is claimed to be lighter and more enduring than the lead cell, and better suited to electric vehicle

service. The active material of the positive plate is peroxide of nickel, and that of the negative plate finely divided iron.

Nickel Plating.—Electroplating an object with nickel, by suspending the object to be plated as the cathode in a nickel bath, while a sheet of rolled nickel forms the anode.

Nickel Silver.—An alloy of nickel, copper, and zinc, usually called German silver.

Nickel Steel.—Ordinary soft steel to which has been added a small percentage of nickel; it has been found that the addition of about three per cent (3.16 to 3.32) produces the most favorable results.

Nigger.—A shop name for any fault encountered in the working of electrical apparatus; a *bug*.

Night Bell.—An electric call bell in a telephone station so connected as to ring continuously until answered by the night operator. Night bells are similarly employed in telegraph and hotel offices.

Night Switch.—In a telephone exchange, a switch by which the switchboard drops are placed in connection with a night bell which summons the operator the instant a drop falls.

Nippers.—Small pinchers for holding, breaking, or cutting wire.

Nipple.—A piece of pipe not exceeding 12 inches in length, threaded at each end. This is the pipemakers' definition; in pipe fitting, any short length of pipe with a male thread on either end; nipples are classified according to length; as, *close*, *short* and *long*.

Nipple of Carbon.—The point formed upon the tip of the negative carbon in a direct current arc lamp, just below the crater of the positive carbon.

Niter, Nitre.—A biting, white nitrate; niter is used in the arts under the name of *saltpeter*, especially in the manufacture of gunpowder.

Nitrate.—A salt formed by the action of nitric acid on a base.

Nitrate of Silver.—A salt employed in silver plating. It is formed by the chemical action of nitric acid upon silver, pure silver being added in small quantities to a warm mixture of one part distilled water to four parts strong nitric acid.

Nitrate of Soda.—The commercial name for sodium nitrate, also known as Chili saltpeter, occurring in immense quantities just below the surface in Peru and Chili.

Nitric Acid.—Also known as *aqua fortis*. A compound of hydrogen, nitrogen, and oxygen. A powerful reagent extensively used in the manufacture of explosives, coal tar colors, commercial nitrates, as an oxidizing agent, etc. In the Grove and Bunsen primary cell, nitric acid is used as a depolarizer. It is also used in silver plating to form the nitrate of silver salt.

Nitro-gelatin.—An explosive compound formed by dissolving finely subdivided gun-cotton in nitroglycerin, and containing over 90 per cent of the latter. It can only be fired by a powerful detonator.

Nitrogen.—A gas possessing mainly negative properties, being ordorless, tasteless, colorless, non-combustible, and a non- supporter of life or combustion; it is an element found in the mineral kingdom, as in the air (forming four-fifths of its volume), in the vegetable kingdom, as a common constituent of plant tissue, and in the animal kingdom, as in the various tissues of the body. Nitrogen has been liquefied; one cubic foot at 32° temperature weighs a trifle less than one ounce.

Nitrogen Fixation.—If a spark or arc discharge be passed through the air, the oxygen and nitrogen of the air are compelled to combine so that the nitrogen of the air is fixed as a useful compound. This process is called the fixation of atmospheric nitrogen. The chief applications are in the production of artificial fertilizers and the preparation of explosives.

Nitroglycerin.—A violent liquid explosive formed by spraying one part glycerin on a chilled mixture of three parts nitric and five parts sulphuric acids. The nitroglycerin floats on the top of the acid mixture, is drained off, washed with an alkaline solution, and then filtered. It is many times more powerful than gunpowder and can be fired whether wet or dry, but its fluidity hinders its use for many purposes. To avoid this difficulty and to diminish the danger of transport, a very porous siliceous earth is mixed with nitroglycerin forming *dynamite*. Dynamite can only be exploded by percussion.

Nobili, Leopoldo.—Born 1784, died 1835. An Italian physicist, inventor of a type of

galvanometer (1825), and discoverer of the so called Nobili's rings (1826).

Nobili's Rings.—A phenomenon observed when electrolysis takes place through a lead solution when the anode is a plate of polished metal lying horizontally under a platinum wire as a cathode. The deposit takes place in rings showing rainbow tints; also called *metallochromes.*

Nodes.—1. In a circuit through which an oscillatory current is passing, points of constant potential located between each loop of vibration.

2. Points in a transversely vibrating body, as a string or wire, which remain at rest between two successive vibrating loops; *nodal points.*

Nodular Deposit.—In electroplating, a deposit of uneven thickness caused by insufficient current density.

Noise.—Sound produced by irregular vibrations, as distinguished from *tone.*

Noisy Arc.—An arc lamp which emits a hissing sound, usually as the result of too much current; *a hissing arc.*

Nominal Candle Power.—The illuminating power at which an arc lamp is rated, being always far above the actual candle power; thus, a so called 2000 candle power lamp has an actual illuminating power equal to only about 875 candles.

Non-arcing Fuse.—A safety fuse made of a non-arcing metal which will melt without forming a voltaic arc.

Non-arcing Lightning Arrester.—A lightning arrester employing fuses made of non-arcing metal.

Non-arcing Metal.—An alloy obtained by uniting certain metals of the cadmium group which have such properties that electrodes made of them cannot sustain a voltaic arc.

Non-automatic Variable Resistance.—A resistance which is adjusted by hand to its variations in strength.

Non-condensing Engine.—One which discharges its steam directly into the atmosphere. The difference between the condensing and non-condensing engines, with equal pressure of steam and expansion, is solely, that the condensing engine has the advantage of the effect produced by the vacuum.

Non-conductor.—1. A substance which does not allow the passage of electricity through it at all, or only in a very small degree; an *insulator* or *dielectric.*

Strictly speaking, there is no substance which will prevent the passage of electricity. The substances named in the following list are more or less efficient in the order in which they are given, the best non-conductor being named first: dry air, glass, paraffin, ebonite, shellac, gutta-percha, resin, silk, wool, porcelain, oils.

The most efficient non-conductors lose their virtue if their surface be moist, the electricity passing by the conducting power of the moisture. This circumstance also shows why it is necessary to dry previously the bodies on which it is desired to develop electricity by friction.

2. Any material which is a poor conductor of heat. Such non-conductors are used as a covering for steam pipes or for retaining the cold in refrigerators, etc.

Non-electrics.—A name formerly erroneously given to metallic substances, chiefly good conductors, which were for a long time supposed to be incapable of being electrified by friction. It was afterwards discovered that if they were mounted on glass handles and then rubbed with silk or fur, they behave as *electrics.*

Non-ferric.—Not containing *iron.*

Non-ferric Inductance.—Inductance exhibited by a circuit which does not contain iron.

Non-ferric Inductance Coil.—An inductance, or choking coil, which does not have an iron core.

Non-ferric Magnetic Circuit.—A magnetic circuit free from iron.

Non-homogeneous Current Distribution.—The passage of an electric current with uneven density through a conductor, as exhibited, for example, in the so called *skin effect.*

Non-illumined Electrode.—In a selenium cell, the electrode which is not exposed to the light.

Non-inductive Circuit.—An electric circuit which possesses a very small amount of inductance. There are no circuits

absolutely non-inductive, but the term is applied to those in which the inductance is so small as to be negligible.

Non-inductive Load.—A load in which the current is in phase with the voltage across the load.

Non-inductive Resistance.—Any resistance free from self induction.

Non-inductive Winding.—A method of arranging a coil of wire in an electric apparatus so that it shall contain no self induction. This may be done by doubling the wire upon itself, and then winding the two parallel halves side by side.

Non-interfering Fire Telegraph.—A system of fire alarm signaling in which two or more calls may be received at the same time without interference.

Non-interfering Street Signal Box.—A fire alarm box, in the non-interfering fire telegraph system, which allows of sending a signal which will not interfere with any others that may be received at the station at the same time.

Non-luminous Heat Radiation.—Radiation of heat waves, which have frequencies such that they are incapable of affecting the optic nerve.

Non-luminous Radiation.—Invisible radiation, as of light waves outside the range of the visible spectrum, and of heat waves which are insensible to the eye; obscure radiation, as distinguished from *light.*

Non-magnetic Steel.—Certain grades of nickel steel, and other steel alloys, which can be rendered practically *unmagnetizable.*

Non-multiple Switchboard.–A telephone switchboard for a small exchange, as distinguished from the multiple switchboard which is necessitated when the number of subscribers exceeds 400 or 500.

Non-oscillatory.—Free from oscillations or vibrations.

Non-oscillatory Charge.—An electrostatic charge produced by currents uniform in direction and flow, as distinguished from a charge by alternating or oscillating currents.

Non-oscillatory Currents.—A current uniform in direction and flow; one free from oscillations or pulsations.

Non-oscillatory Discharge.–A discharge of electricity which is not oscillatory in character.

Non-oscillatory Intermittent Current.—A pulsating current having uniform direction; a direct, but not steady current.

Non-periodic Alternating Current.—An alternating current which rises and falls in strength without periodicity of change.

Non-polarizable Electrodes.—In electro-therapeutics, electrodes designed to be free from polarization.

Non-polarized Relay.—In telegraphy, a relay with an electromagnet which has an unmagnetized armature; a *neutral* relay.

Non-reactive Circuit.—An electric circuit having ohmic resistance only, without capacity resistance or inductance.

Non-return Valve.—An automatic valve, sometimes a hinged clack, but more frequently of the same pattern as an ordinary stop valve disconnected from its spindle; it opens with the pulsation of a pump to pass the water, and closes as soon as the flow ceases, preventing a backward rush of the water under pressure. A boiler feed check is the most familiar example of a non-return valve. Usually called a *check valve.*

Non-sinusoidal Current.—An alternating current in which the wave shape is distorted from the true sinusoid form.

Non-synchronous Motor.—A term sometimes applied to the *induction motor,* in which the currents supplied from the external source are led through the field coils only, the armature not being connected with the external circuit, but being rotated by currents induced by the varying field set up by the alternating currents in the field coils. Either the field or the armature may be the revolving member.

Non-uniform Magnetic Flux.—Magnetic flux existing in varying densities through a magnetic circuit.

Non-vibrating Filament.—An incandescent lamp filament fastened at a point in the loop to a small iron or nickel wire fused into the glass so as to prevent vibrations which would shorten the life of the lamp.

Lamps with a filament *anchored* in this way are designed for use in street cars or wherever they would be subject to severe vibration.

Normal.—Conforming to established rule.

Normal Current.—The electric current which meets the requirements of an electric system or machine when operating under normal conditions.

Normal Earth Currents.—The electric currents flowing naturally through the earth under usual conditions.

Normal Magnetic Day.—A day in which there are no extraordinary variations in the earth's magnetic elements.

Normal Voltage.—The voltage required for an electric system or machine when operating under normal conditions.

Normal Voltaic Arc.—A voltaic arc exhibiting no extraordinary characteristics.

North.—That one of the four cardinal points of the compass, at any place, which lies in the direction of the true meridian and *to the left hand of a person facing the east*; the direction opposite to the south.

North Pole.—That point on the earth, ninety degrees from the equator, *toward the north*.

North Pole of Magnet.—The pole of a magnet, or magnetic needle, which tends to point to the north; also known as the *boreal*, marked, north seeking, positive, plus (+), and red pole.

North Seeking Pole.—The north pole of a magnet.

Nose Motor Suspension.—A method of suspending a motor upon a car truck, in which one side of the motor case rests upon the axle, while a projecting lug upon the other side rests upon a steel crossbar.

Notch Wire Gauge.—The usual pattern of wire gauge provided with notches, corresponding in width to the different numbers or thicknesses of wire, disposed around the circumference of a plate of circular or other convenient form.

N Rays.—A peculiar kind of rays, discovered by Prof. Blondlot of the University of Nancy to be emitted by a Crookes tube, a Nernst lamp, the sun, and other sources, and to have properties quite distinct from those of X-rays, and from those emitted by radioactive bodies like radium or uranium.

Null Method.— A method of making electrical measurements in which comparison is made between two quantities by reducing one to equality with the other, the absence of deflection from zero of the instrument scale showing that the equality has been obtained; the *zero method*.

Null Point.—A term sometimes applied to the *node* or the point in a vibrating body which remains at rest.

Number 1 Side of Quadruplex System.—In telegraphy, that portion of the quadruplex which causes and responds to the reversals of polarity.

Number 2 Side of Quadruplex System.—In telegraphy, that portion of the quadruplex which causes and responds to the increase and decrease of current strength.

Nut Lock.—In machinery, the device adopted for securing a nut in place so that it shall not slacken back and become loose in consequence of vibration. Usually called *lock nut*.

o.—Abbreviation for *ohm*, the practical unit of *electrical resistance*.

Ω—The Greek capital letter "*omega*," used as a symbol for the *megohm*.

ω—The Greek small letter "*omega*," used as a symbol for the *ohm*.

Oak.—The most important of all hard woods; it has a strong grain, often showing handsome figures, that obtained by sawing the wood quarterly being termed *quartered oak*. Its color is from light grayish yellow to dark brown, and it takes a high polish. Oak is employed on heavy work where great strength and durability are required, as in piles, ship building, and building construction, especially where exposed to the weather; also for furniture and inside decoration.

Oblique and Parallel Circuit Laws.—The following are the laws which apply to oblique and parallel circuits as discovered by Ampère.

1. *Two portions of circuits crossing obliquely attract each other if both the currents run either towards or from the point of crossing, and repel each other, if one runs to, and the other from that point.*

2. *Two parallel portions of a circuit attract each other if the currents in them are flowing in the same direction and repel each other if the currents flow in opposite directions.*

3. *The force exerted between two parallel portions of circuits is proportional to the product of the strengths of the two currents, to the length of the portions, and inversely proportional to the simple distance between them.*

Obliquity of Connecting Rod.—In mechanical engineering, this signifies the angle made by the connecting rod of a steam engine when the crank pin is at any point of its path except at the dead centers, the extreme upper and lower portions of its path, respectively. The effect of the obliquity is to cause the slide valve to open the ports unequally at each end, the port being closed and opened a little earlier at one end than at the other. Partly for this reason the connecting rod is always made as long as circumstances will permit in order to diminish the amount of *obliquity*.

Obscure Radiation.—1. That portion of the radiation from a light source which fails to emit light, but passes off in heat.

2. In a luminous spectrum, radiation existing beyond the violet rays, invisible to the eye, but known by their chemical action as *actinic* or *chemical* rays.

Occlusion of Gases.—A property, possessed by all substances in varying degrees, of absorbing particles of gas, especially when the substance is heated and then allowed to cool in contact with the gas.

Occlusion Process.—A method of reducing the residual gas in a vacuum, by which the exhausted chamber is subjected to a heating process, resulting in the absorption of a certain amount of gas by the heated walls of the chamber.

Ocean Cable.—A telegraph cable designed to rest upon the bed of the ocean for submarine telegraphy; a *submarine cable*.

Octo-polar Dynamo.—A multipolar dynamo provided with eight field magnet poles.

Octo-polar Field.—An electromagnetic field produced by a group of eight field magnet poles.

Od.—A supposed force alleged by Reichenbach to account for the phenomena of mesmerism, or animal magnetism.

Odorscope.—An apparatus for testing odors, in which a carbon contact is designed to be so influenced by the action of the odor as to affect the indication of a galvanometer.

Odylic Rays.—Alleged streamings of the od force supposed to be emitted from certain crystals, or from poles of magnets, and especially from peculiarly sensitive persons who thereby exhibit the power of mesmerism.

Oersted.—The unit of reluctance or magnetic resistance, being the reluctance offered by a cubic centimeter of vacuum.

Oersted, Hans Christian.—Born 1777, died 1851. A Danish physicist, noted for his experiments on the magnetic needle

with the electric current; he discovered (1820) that a magnetic needle was deflected by an electric current in a wire passing over and under it, and he first suggested the idea (1821) that light is a manifestation of electromagnetism.

Oersted's Discovery.—The important discovery, made by Hans Christian Oersted, the Danish scientist, in 1819, of the magnetic effects of the electric current. In 1820, he showed that a magnet tends to set itself at right angles to a wire carrying an electric current. He also found that the way in which the needle turns, whether to the right or to the left of its usual position, depends upon the position of the wire that carries the current, whether it be above or below the needle, and on the direction in which the current flows through the wire.

Office Cable.—A cable connecting a telegraph, or other office, to the main circuit; an electric cable adapted to indoor service.

Office Loop.—In telegraphy, a pair of wires leading to an office, or two wires leading to an operator's desk within a telegraph office.

Off Position of Switch.—The position of a switch when the part of a circuit it controls is cut out of the main circuit.

Offset.—In a conduit system of electrical distribution, a branch connection for joining a service wire to the conductors; a *lateral.*

Ohm.—The practical unit of electrical *resistance,* equal to 10^9 C. G. S. electromagnetic units. It is named for G. S. Ohm, the German scientist. An ohm is equal to the resistance offered to an unvarying electric current by a column of mercury at 32° Fahr.. 14.4521 grams in mass, of a constant cross sectional area, and of the length of 106.3 centimeters The value of the ohm, determined by a committee of the British Association in 1863, called the B. A. unit, was the resistance of a certain piece of copper wire. The so called *legal ohm* as adopted at the International Congress of Electricians in Paris in 1884, was a correction of the B. A. unit and was defined as the resistance of a column of mercury one square millimeter in section and 106 centimeters long, at a temperature of 32° Fahr.

Ohmage.—The resistance of an electrical circuit in ohms.

Ohm, Georg Simon.—Born 1787, died 1854. A German physicist, noted for his researches with electric currents. He formulated (1827) the law known as Ohm's law, which underlies all modern electrical theory and measurement.

Ohmic.—Relating to true electrical resistance measured in ohms.

Ohmic Drop.—Drop in electrical potential consequent upon ohmic resistance; *ohmic loss.*

Ohmic Loss.—The ohmic drop or loss of potential in a circuit due to the resistance offered to the current by the circuit. It equals the product of the current by the resistance.

Ohmic Resistance.—The true resistance in an electric circuit, as distinguished from the counter-electromotive force, or *spurious* resistance in the circuit.

Ohmmeter.—A form of galvanometer for measuring electrical resistance, in which a pointer indicates directly the number of ohms in the resistance under measurement.

Ohm Mile.—The *mile ohm,* a wire one mile in length and having a resistance of one ohm.

Ohm's Law.—The law that, considering a steady flow of electricity in a given circuit, *the amount of current in amperes is equal to the electromotive force in volts divided by the resistance in ohms;* this law was first announced by Ohm, the German scientist, from whom it received its name.

The law may be expressed in three simple formulas, when I is used as the symbol of the current strength in amperes, R as that of the resistance in ohms, and E equals the electromotive force in volts, as follows:

1. $I = \frac{E}{R}$, which reads: The current in amperes equals the electromotive force in volts divided by the resistance in ohms.

2. $E = IR$, which reads: The electromotive force in volts equals the current in amperes multiplied by the resistance in ohms.

3. $R = \frac{E}{I}$, which reads: The resistance in ohms equals the electromotive force in volts divided by the current in amperes.

Oil.—A substance expressed or drawn off from various animal and vegetable matters. It is insoluble in water, but is sometimes soluble in alcohol, and always in ether; it has been found to consist of glycerin, a sweet, thick, syrupy liquid, united with animal and mineral acids. Stearin and margarin prevail in the solid fats and olein in the liquid oils. There are also mineral oils.

Oil Bath.—A bath or reservoir of oil, in which revolving parts subject to excessive

friction are partially or wholly immersed, to provide them with constant lubrication. Worm gearing, when run at a high speed, is often immersed in an oil bath.

Oil Break Switch.—A type of circuit breaker employed in transmission lines for breaking the circuit under oil.

Oil Cooled Transformer.—A transformer employing oil instead of air as the cooling agent, the oil itself being maintained at a low temperature by a flow of cold water through spiral tubes within the transformer case.

Oil Damping.—A method of bringing the moving parts of an electric measuring instrument quickly to rest by means of the resistance offered to a vane or paddle by the oil in which it is immersed.

Oil Insulation.—Insulation in electrical work by the use of oil. Paraffin oil, for instance, is a liquid which has great insulating properties. On account of its high specific resistance, a thin film suffices to prevent leakage from one conductor to another, even though the potential difference between them be considerable.

Oil Insulation for Storage Battery.—The use of resin oil, or some other non-evaporating oil, in the cups of the mushroom insulators upon which the storage cells rest.

Oil Paper.—Oil saturated paper sometimes used for insulation purposes.

Oil Switch.—In high tension electric transmission, a form of circuit breaker designed to effect the breaking of the circuit under paraffin oil; an *oil break switch*.

Oil Transformer.—A transformer which is kept insulated by being immersed in oil, which serves to insulate the coils from each other and the core, and at the same time acts as a cooling medium by conducting the heat away from the coils to the air or to a system of water pipes.

Okonite.—A compound of high resistance employed for insulation purposes.

Olein.—A colorless oily liquid compound, the chief part of fatty oils; in its pure form it constitutes olive and almond oils.

Olivette Box.—An apparatus for throwing a flood of colored light upon a stage, consisting essentially of an arc lamp enclosed in a box having a window of colored glass.

Omnibus Bars.—Commonly called *bus bars*, the main switchboard conductors to which the current is led from an electric generator through suitable cables, switches and indicating instruments.

Ondographe.—A form of curve tracer, devised by Hospitalier, for indicating the shape of an alternating current wave.

One Coil Transformer.—An *autotransformer*, a form of stationary induction apparatus having only one coil, any part of which may be used as a primary and any part as a secondary.

One Fluid Cell.—A primary cell containing a single electrolyte, such as dilute sulphuric acid, into which the plates dip, as distinguished from the *two fluid* cell employing a liquid depolarizer.

One Fluid Theory.—A theory of electricity proposed by Benjamin Franklin. According to this theory there is a single electric fluid uniformly distributed in all bodies, but when a body is subjected to friction, the electricity becomes unequally distributed between the thing rubbing and the thing rubbed, creating a condition known as *positive* and *negative* electricity, according as one body has more or less of the fluid than the other.

One Layer Armature Winding.—A method of armature winding which requires only one layer of wire.

One Way Door Trigger.—A door trigger which gives an electrical signal only when the door is opened.

"On Position" of Switch.—The position of a switch when the part of a circuit it controls is placed in connection with the main circuit.

Onyx.—A kind of quartz, resembling agate, made up of layers of different colors, often sharply defined. Varieties which are brought from Algeria and Mexico are now used largely for decorative finish, building purposes, etc.

Oolite.—A limestone composed of small grains, more or less spherical in appearance, each formed of concentric coats of calcium carbonate around a nucleus, usually a grain of sand; used for building, and valued on account of the ease with which it may be

worked and its soft and pleasing color. Also known as oolitic *freestones* and *Indiana marble.*

Ooze.—To discharge slowly; to flow through something or leak out imperceptibly.

Opaline.—Tradé name for a translucent glass designed to soften and diffuse the light of an electric lamp.

Opaque.—Not having the power of transmitting light; impervious to light rays.

Open Arc Lamp.—Any form of arc lamp in which the air has free access to the arc, as distinguished from the *enclosed arc lamp*, from which the air is largely excluded.

Open Box Conduit.—A simple form of underground conduit consisting of an open wooden trough of sufficient size to contain the cables; after the cables are laid it is completed by filling with hot pitch and nailing on a wooden cover.

Open Circuit.—A circuit, the electrical continuity of which has been interrupted; *a broken circuit.*

Open Circuit Battery.—A battery of open circuit primary cells, designed only for intermittent use, such as ringing electric bells, and especially for telephone work. The cells soon become exhausted upon closed circuit, but regain working order while resting between periods of activity.

Open Circuit Burglar Alarm.—An alarm rung by an open circuit battery, the circuit of which is momentarily closed by a contact made by an opening door or window.

Open Circuited.—Having a broken or interrupted circuit.

Open Circuited Conductor.—A conductor whose electric continuity is interrupted, not forming a completed circuit.

Open Circuited Discharge.—An electric discharge effected through a broken circuit.

Open Circuit Induction. — Inductive effects produced in open circuits due to oscillatory discharges taking place in neighboring circuits; *oscillatory induction.*

Open Circuit Primary Cell.—Cells, of which the Leclanchè cell is an example, normally kept on open circuit for use in intermittent work. They quickly become exhausted on closed circuit, but gradually recover when the circuit is opened again.

Open Circuit System.—In telegraphy, a system of signaling in which the battery is placed to the line only when a message is being transmitted, at other times remaining on open circuit.

Open Circuit Thermostat.—A thermostat the heating of which opens a circuit.

Open Circuit Transformer.—A transformer making use of the air to complete its magnetic circuit; an aero-ferric-circuit transformer; *a polar transformer.*

Open Coil Armature.—An armature so wound that the coils are kept separate, each coil, in its simplest form, having a separate two part commutator, so that each commutator segment has only one end of one coil connected with it; the coils being open or disconnected at the commutator when the brushes are removed.

Open Coil Disc Armature.—An open coil armature of the disc type.

Open Coil Drum Armature.—An open coil armature of the drum type.

Open Coil Dynamo.—A dynamo having an open coil armature.

Open Coil Ring Armature.—An open coil armature of the ring pattern.

Open Hearth Process.—A method of making steel in large quantities from pig iron and ore, by melting the materials in a bath formed as the hearth of a reverberatory furnace. The furnace was originally invented by *Sir Charles Siemens*, whose name is inseparably associated with the process.

Open Iron Magnetic Circuit.—A magnetic circuit that is completed partly through metal and partly through air; an *aero-ferric* magnetic circuit.

Open Magnetic Core.—A magnet core in an open iron magnetic circuit.

Open Work.—A method of running electric wires in buildings so that the wires are in plain sight upon the walls and ceilings, being supported by porcelain cleats or knobs; *cleat work.*

Operator's Position.—At a multiple telephone switchboard the place occupied by an operator before a particular section, provided with a complete operator's equipment.

Operator's Set.—The telephone equipment of an operator's position at a section of a multiple switchboard; the set used by an operator at a telephone exchange.

Operator's Shelf.—A shelf at a telephone switchboard upon which the operator's equipment is placed.

Opposed Electromotive Forces.—Electromotive forces acting in opposition to one another.

Opposed Magnetomotive Forces.—Magnetomotive forces acting in opposition to one another.

Opposite Poles.—Magnetic or electric poles of different, unlike or opposite sign; thus, north (n) and south (s), or positive (+) and negative (–) are opposite poles.

Opposition.—In an alternating current circuit, if the angle of lag or of lead between two series of waves be 180°, the waves are said to be in *opposition.*

Optical Efficiency of Light.—The ratio between the heat rays, or obscure radiation, and the light rays, or luminous radiation, emitted by a source of light.

Optical Indicator.—An apparatus for taking indicator diagrams of internal cumbustion engines, in which the diagram is traced by a ray of light reflected upon a ground glass screen or on a photographic plate; *the manograph.*

Optical Pyrometer.—A type of radiation pyrometer for extra high temperature measurement. It is based upon the relation of color and temperature in glowing "black bodies," the color of such a body changing with increasing temperature from red to yellow and finally to white. The temperature is viewed through a tube containing a small glow lamp connected to a battery through an ammeter and a resistance. The point of disappearance of the filament is noted by the ammeter reading and the corresponding temperature found from a table.

Optic Axis.—A line with reference to which the eye is symmetrical, being a straight line passing through the pupil and crystalline lens; *the axis of the eye.*

Oral Annunciator.—An electric annunciator operating in connection with a speaking tube; a *speaking tube annunciator.*

Ordinary Jacks.—In a multiple telephone switchboard, the multiple jacks which are duplicated at each section of the board, as distinguished from the *answering* jacks belonging only to those lines whose calls are received at a particular section.

Ordinary Lines.—In a call wire telephone system, the lines over which conversation is carried on between subscribers, as distinguished from the call wires by which the exchange is called up.

Ore.—The native form of a metal, whether free or uncombined; as, gold, copper, etc., or combined; as, iron, lead, etc.; the deposit in which a metal is mineralized together with veinstone or gangue, whence it has to be mechanically freed by dressing, and chemically by smelting.

Ore Concentrating.—In mining, the process of sorting ores according to richness or of separating the metallic portions of powdered ores from the *gangue.* There are two processes, the dry and the wet. In the *dry process,* the main principle is a blast of air, carrying or blowing the ores according to their weight, the quantity of metal determining the relative weight. According to their weight, the ores fall down and are thus separated, the very light parts being blown away as dust. In the *wet process,* the ore is put in a machine which has a circular, concave grooved disc, with a continuous rotary motion. The ore and water are received at the center and carried by centrifugal force to the rim of the disc, the heavier particles settling in the *riffles.* The debris, separated by the current and constant agitation, is carried out by the sluice across the disc to the center, and is discharged through openings into the stationary circular sluice below.

Organ, Electric.—A pipe organ in which the wind is sent into the pipes under electrical control.

Organic Chemistry.—The branch of chemistry which treats of the substances which form the structure of organized beings and their products whether animal or vegetable; called also *chemistry of the carbon compounds.*

Orientation of Magnetic Needle.—The arriving of a magnet needle at a position of rest in the earth's magnetic meridian.

Originating Call.—The original call of a subscriber received at a telephone exchange, requesting connection with another subscriber.

Originating Operator.—The operator at a telephone exchange who receives the originating call and transmits it to another station, when the communication involves more than one exchange in its delivery.

Oscillating Current.—An electric current consisting of a succession of waves of constant length, decreasing in amplitude in constant proportion; an *oscillatory current.*

Oscillating Current Transformer.—A transformer in the circuit of an oscillating current.

Oscillating Discharge.—An oscillatory or surging, discharge; the discharge of a condenser through a circuit; the sudden make and break of a circuit; the electrostatic charge in a circuit caused by a lightning stroke; all giving rise to oscillating currents.

Oscillating Electromotive Force.—An electromotive force having a constant period of vibration, but with varying amplitude; the *electromotive force of an alternating current.*

Oscillating Intermittent Currents.—Oscillating currents of the type produced by the discharge of a static condenser.

Oscillating Needle.—A needle employed to measure a magnetic force by the number of oscillations it makes when disturbed from a state of rest in a magnetic field. It follows a law similar to the law of a vibrating pendulum, that the square of the number of oscillations in a given time is proportional to the force.

Oscillating Stresses.—In mechanics, stresses by which structures, or the members of structures, are placed alternately in tension and compression; as, for example, in counterbraced structures subject to alternate moving loads. The conclusions deduced from the experiments in this direction show that when a bar is subject to these oscillations in stresses, the total stress on the bar is equal to their sum; that is, supposing a tensile stress of two tons and a compressive stress of two tons, alternately applied, the equivalent is a total stress of four tons.

Oscillation.—1. A moving backward and forward; vibration; swinging, like a pendulum.

2. When the frequency of an alternating current rises to the value of a million or so, the current is termed an *electric oscillation,* especially in wireless telegraphy.

Oscillation Constant.—In circuits containing electric vibrations, the square root of the capacity of the circuit multiplied by the square root of the self induction is called the oscillation constant of the circuit. In different circuits having the same oscillation constants, the natural periods of vibration are the same.

Oscillation Frequency.—The number of complete periods executed in a second of time by a rapidly alternating electric current is called the *frequency* of its alternations or oscillations.

Oscillations, Electric.—1. In wireless telegraphy, electromagnetic waves set up in the ether by the transmitting instrument or oscillator.

2. The discharge, of a vibrating character, produced by a condenser, such as a Leyden jar, through a conductor of low resistance.

3. The oscillating currents caused by the disturbed equilibrium of an electric circuit.

Oscillator.—A device for creating electric oscillations, especially in wireless telegraphy.

Oscillatory.—Having a swinging or vibratory movement.

Oscillatory Charging.—Producing an electric charge by the use of an oscillating current.

Oscillatory Dynamo, or Generator.—A form of dynamo in which the armature, instead of rotating, performs oscillatory movements in the electromagnetic field; a *tuning fork dynamo.*

Oscillatory Inductance.—Inductance produced in a circuit possessing electrical oscillations.

Oscillograph.—An instrument for determining the form of alternating current waves. It is in reality a galvanometer having a moving system capable of extremely rapid vibration, fitted with a suitable arrangement for recording the vibrations. The deflection at any instant is practically proportional to the current flowing through it at that instant, in spite of the fact that the current may be varying very rapidly in strength and direction. It must be critically damped, as any tendency to overshoot would distort the wave form from its true shape.

A new use for the oscillograph is found in the investigation of the oscillations which occur when switching off a continuous current in an inductionless circuit. A record is obtained photographically

showing most clearly simultaneous variations of different amplitudes. It is suggested that a valuable application of the oscillograph to wireless telegraphy may be made in this way.

Osmin Lamp.—A type of tungsten incandescent lamp manufactured in Vienna. It has a squirted filament of powdered tungsten prepared by a colloidal process and held together by an organic binding material. This lamp shows remarkable life and high efficiency.

Osmium.—A rare metal employed as a filament in a certain type of incandescent lamp. It is nearly twice as heavy as lead, and is almost infusible. It is malleable and ductile with high electric resistance. The pure metal is not drawn into fine wire for filaments, but finely divided osmium is mixed into a paste which is forced through dies producing threads which are *formed* by heating by an electric current in the presence of certain gases.

Osmium Lamp.—A type of incandescent lamp used to some extent in European countries. It was invented by Dr. Welsbach who designed the Welsbach burner. The filament composed of pure porous osmium is made in long U shaped loops anchored to a glass rod in the base of the bulb. Osmium lamps have long life and great candle power with low watt consumption.

Osmometer.—An instrument for measuring the action of osmose.

Osmose.—The tendency of liquids, differing in density, to pass through an intervening porous partition, and to mix or become diffused.

Osmose, Electric.—The passage of an electrolyzed liquid into another liquid through an intervening porous partition; also called *osmosis*. Porret observed that if a strong current be led into certain liquids, a porous partition being placed between the electrodes, the liquid is carried by the current through the porous partition, until it is forced up to a higher level on one side than on the other. This electric action is most pronounced when the experiment is made with liquids, which are poor conductors. The movement of the liquid takes place in the direction of the current.

Osmotic Pressure.—The pressure exerted between liquids of different densities, which gives rise to the phenomenon of osmose.

Osteotome, Electric.—A surgical saw operated by electricity.

Otto Cycle.—The four phase cycle commonly employed in internal combustion engines, giving an impulse each alternate revolution or every fourth stroke.

After explosion: (1) the return or *exhaust* stroke of the piston expels the products of combustion from the cylinder; (2) the *suction* or next outward stroke draws in a fresh charge of gas or vapor with the properly proportioned dilution of atmospheric air; (3) the *compression* or return stroke which compresses the charge into the clearance preparatory to (4) the *explosion* which does work on the piston. Usually called *four cycle*.

Out and Out.—A shop term, signifying an outermost dimension embracing the extreme extent of the dimension. Also called *over all*.

Outboard Bearing.—The bearing of an electric generator on the commutator end.

Out Current of Telephone Relay, or Repeater.—The current of the local circuit connected with a telephone relay, which current acts on the second line wire with reinforced strength when influenced by the receiver diaphragm of the first line.

Outdoor Transformer.—A transformer intended for use out of doors; a *street transformer*.

Outer Circuit.—The external circuit, or the portion of an electric circuit not included within an appliance.

Outers.—In the three wire system of electrical distribution, the positive and negative mains as distinguished from the central neutral wire.

Outgoing Call.—A call sent from a telephone exchange, as distinguished from a call received by the exchange.

Outgoing Call Trunk Line.—A telephone trunk line employed at an exchange for issuing outgoing calls.

Outgoing Current.—In telegraphy, the current sent out by a station over the line, as distinguished from a current received at the station, or from the return current.

Outgoing End.—The end of a telephone line at which outgoing calls are issued from an exchange.

Outgoing Lines.—Telephone lines over which calls are issued by an exchange.

Outgoing Signals.—In telegraphy, signals sent out by a station, as distinguished from the incoming signals at that station.

Outgoing Wires.—Any wires leading out from a place or apparatus.

Outlet.—A point in a ceiling, wall, or elsewhere, out of which wires are led for making electrical connection with lamps or other devices.

Outlet Block.—A safety cut out located at an outlet.

Outlet Box.—A box located at an outlet to enable proper connections to be made between the outlet conductors and the branch wires.

Outlet Insulator.—An insulator for electrically safeguarding an outlet.

Out of True.—A shop term, signifying inaccuracy of work. A winding piece of board or metal, or a wobbling or eccentric piece of lathe work is said to be *out of true.*

Output.—1. The rate of useful energy delivered by a machine.

2. The quantity of anything manufactured, or produced in a works or mine during a stated period.

Output of Dynamo.—The available electrical energy delivered by a dynamo at its terminals, measured in watts or kilowatts.

The output of a dynamo is classified as *gross* and *net.* The gross output being the number of amperes multiplied by the total voltage developed; the net output being the number of amperes multiplied by the volts at the terminals.

Outrigger.—A horizontal bar attached to a telegraph pole in order to truss it against a lateral strain.

Outrigger for Arc Lamp.—An arm for suspending an arc lamp at the desired distance beyond its support.

Outside Air Gap.—A device used in jump spark ignition, consisting of two adjustable electrodes, having their terminals slightly separated and placed in the secondary circuit in series with the plug. Its object is to prevent any leakage of current in case of defective plug insulation by preventing the flow of the secondary current until the voltage has been raised enough to suddenly break down the resistance at the outside gap and also that at the plug. This results in a discharge through the air gap of the plug, instead of over the sooted surfaces of the plug insulation. As usually constructed the outside gap consists of two adjustable electrodes, set into a short piece of glass tubing. Also known as an *auxiliary air gap.*

Outside Wiring.—Wiring that is attached to the surface. *Not concealed.*

Outside Work.—1. Work executed outside a shop, in distinction to shop work.

2. Outside wiring.

Outward Flow.—In hydraulics, a turbine is said to have outward flow when the water enters at the center and escapes radially through the revolving blades in an outward direction.

Oval.—1. An egg shaped figure; an ellipse constructed with three axes, one of the minor axes being shorter than the other.

2. A common term for an ellipse.

Over Compounding.—Increasing the series windings in a compound wound dynamo in order that it may preserve a constant voltage at the extremities of its circuit.

Overflow of Leyden Jar.—A disruptive discharge of a Leyden jar which sometimes takes place around its rim.

Overhaul.—To inspect carefully or to examine the conditions of; to haul over; also to examine, as accounts, item by item.

Overhead Conductor.—A conductor suspended overhead, as distinguished from one placed underground; an *aerial conductor.*

Overhead Feeders.—Feeders in overhead construction, as distinguished from those put underground.

Overhead Lines.—Lines of any electric system carried overhead, or overground, instead of being run underground.

Overhead Mains.—Electric mains carried overhead.

Overhead Switch.—Any switch located overhead; also called *canopy switch.*

Overhead Telegraph.—The ordinary telegraph system running overland along overhead lines.

Overhead Traveler.—In machinery, it usually consists of a crab mounted on a gantry and worked either by hand, steam or electricity. The advantage of overhead

travelers is that they leave a clear space for working underneath, and travel up and down and across the shop without interfering with the operations on the floor. The gantry truss is carried on girders or beams at each side of the building.

Overhead Trolley System.—The ordinary system of electric traction, employing *overhead trolley wires.*

Overlapping Block System.—A railway block system in which the signals, operated by a train as it enters a section, are situated at some distance behind the entrance of that section.

Overlap Splice.—A splice in which the strands of the rope are laid over one another, instead of interweaving.

Overload.—A load greater than that which a machine is designed to carry.

Overload Capacity.—The capacity which an electrical machine or apparatus has of carrying an overload without suffering serious injury by heating, sparking, or mechanically weakening.

Overload Circuit Breaker.—A switch operated by electromagnets so as to open the circuit when the current becomes too strong.

Overloaded Conductor.—An electric conductor carrying an excessive current.

Overload of Dynamo.—It may happen through some cause or other that a greater output is taken from the machine than it can safely carry. When this is the case, the fact is indicated by excessive sparking at the brushes, great heating of the armature and other parts of the dynamo, and possibly by the slipping of the belt (if a belt-driven machine), resulting in a noise. The causes most likely to produce overload are: (a) excessive voltage; (b) excessive current; (c) reversal of polarity of dynamo; (d) short circuits or grounds in dynamo, or external circuits.

If at any time it be necessary to run an engine driving a shunt or compound dynamo at a lower speed than the normal, the voltage and output of the dynamo can generally be maintained at their ordinary value by coupling up the shunt coils in parallel, thus increasing the strength of the current flowing in the shunt circuit and the strength of the field correspondingly. Care should be taken, however, that the coils do not overheat with the increased current.

Overload of Motor.—An excessive mechanical load put upon an electric motor, so that it fails to operate economically, and is in danger of injury from overheating, etc.

Overload Storage Battery Switch.—An automatic switch controlling the discharge of a storage battery, cutting the battery out of the circuit when the rate of discharge becomes too great.

Overload Switch.—An automatic switch for breaking a circuit in case of an overload.

Over Maximal Contraction.—The further contraction of a motor nerve which occurs upon increased excitation after it has been subjected to apparent utmost stimulation.

Over Pressure.—The pressure of steam in a boiler beyond that which it is designed to sustain. It is a relative term, depending on the capability of each boiler itself. A pressure greater than the *safe working pressure.*

Over Running of Incandescent Lamps.—Applying a voltage above the normal to an incandescent lamp system, thereby increasing the luminosity, or brightness, but, at the same time, shortening the life of the lamps.

Overshooting.—A phenomenon of momentary excessive brightness in the filament of a tungsten incandescent lamp when first turned on after having been out of service for a considerable period.

Overtone Currents.—Alternating electric currents having higher harmonic frequencies than the first harmonic or fundamental wave.

Overtones.—In sound waves, certain higher harmonics associated with the first harmonic or fundamental tone. These overtones may be compared to the succession of shades by which one color of the spectrum passes almost imperceptibly into another, even while not interfering with the eye's sensation of seven colors.

In one kind of instrument, such as the piano, one set is intensified, and in another, such as the violin, another set; and it is this fact that gives the characteristic difference between a piano and a violin note, although the "fundamentals" may be the same in both. Thus in a musical note the ear finds three things: the loudness of the note, its pitch or tone, and its timbre or quality.

Overtones, Electric.—The higher harmonics of alternating current frequencies, associated with the first harmonic or fundamental wave.

Overtype Dynamo.—A dynamo in which the armature is placed above the field magnet coils and yoke.

Overtype Field Magnet.—A field magnet employed in an overtype dynamo in which the armature is placed above the field magnet coils and yoke.

Over Wound Series Motor.—A series motor provided with exceptionally strong series winding.

Oxidation.—In chemistry, the act of combining with oxygen, or subjecting to the action of oxygen or of an oxidizing agent.

Oxide.—A compound of oxygen with another element; some oxides unite directly with water to form acids, others form hydroxides, while the peroxides, which contain a greater proportion of oxygen than the rest, have only very feeble acid or basic properties.

Oxide Filament Lamp.—An incandescent lamp, like the Nernst, which employs refractory metallic oxides of the rare earths, also lime, magnesia, etc., for incandescence. They are non-conductors in the cold state, but become conductors when heated.

Oxide of Iron.—Ferric oxide, prepared from ferrous sulphate or green copperas by the action of great heat. The more calcined portions are graded to form the varieties of *crocus*, the softer portions are termed *rouge*, both being used for polishing.

Oxygen.—In chemistry, the vital or life giving element in the atmosphere. Its presence is essential to combustion and it enters into combination with the carbon in fuel to produce heat in furnaces. In union with metals it forms oxides.

Oxyhydrogen Flame.—An intensely hot flame produced by the combustion of hydrogen or of coal gas in oxygen gas. The temperature of this flame is sufficient to melt very refractory substances, while certain infusible bodies such as lime can be brought by this flame to a brilliant incandescence; often called *limelight*.

Oxyhydrogen Gas.—A mixture of oxygen and hydrogen to form the gas employed in the oxyhydrogen flame. The two gases being furnished in steel cylinders, they are allowed to mix with a considerable excess of hydrogen in a small chamber leading to a *mixing jet*.

Oyster Fitting.—A fitting used for incandescent lamps in water tight compartments on ships.

Ozite.—A product of the distillation of petroleum, mixed with fibrous material to form an insulating covering for electrical conductors.

Ozokerite.—A waxlike, resinous mixture of natural paraffins, used for insulating electric conductors.

Ozone.—A faint blue gas with characteristic smell produced when a silent electric discharge is passed through the air, changing the oxygen into ozone. Ozonizers are operated by high tension alternating currents, spark or arc discharges being guarded against by providing a dielectric between the electrodes. Ozone is used commercially for bleaching, purifying and sterilising, especially in the sterilisation of water.

Ozoniser.—An apparatus for generating ozone. It consists usually of two conducting surfaces insulated from each other and separated at such a distance that when oppositely charged a "silent discharge" will take place between them. The oxygen of the air under the electric influence recombines into ozone which contains three atoms.

P.—1. The symbol of electric power, or the *watt.*
2. Abbreviation for *power.*
3. Abbreviation for *pressure.*

Φ—The Greek capital letter *phi*, used as a symbol for quantity of *magnetic flux.*

π—The Greek letter *pi*, universally employed in mathematics to denote the ratio of the circumference of a circle to its diameter. This is an irrational number 3 1415 + which has been calculated out to some 500 decimal places by various authorities. π is generally taken as 3.1416 or for mental arithmetic as $\frac{22}{7}$; the first ratio is sufficiently accurate for all practical purposes as, in a circle one mile in diameter, the error of circumference is barely $\frac{1}{16}$ inch too large.

Pachometer.—An instrument for measuring thickness.

Pacinotti, Antonio.—Born 1841. An Italian physicist and electrician, inventor of the first dynamo with a ring armature (1864), afterwards developed by Gramme.

Pacinotti Armature.—A form of ring armature invented by Pacinotti, consisting essentially of a toothed iron wheel carrying its conductors in the depressions between the teeth.

Pacinotti Projections.—Projections or teeth upon the ring armature invented by Pacinotti, between which the armature coils are wound; *Pacinotti teeth.*

Pack.—To supply or surround, as, a joint, with a substance or device to prevent leakage; to fill up a space in or around; as a stuffing box to make it fluid tight; as, to pack a piston rod.

Packfong.—A Chinese alloy, containing about forty parts of copper, twenty-five of zinc, and thirty-two of nickel; also called *white copper.*

Packing.—1. Any material used to pack, fill up, or make close; as, the substance around the piston of a pump or other tube, to render it water or air tight.
2. The cotton waste, used to fill journal boxes, which saturates with oil and holds it against the bearing.
3. A term colloquially applied to the thin sheets of material used for jointing flanges, etc.

Packing of Telephone Transmitter.—A trouble arising in granular carbon or dust transmitters from the gradual settling of the carbon particles until they form a compact mass between the diaphragm and the back electrode, seriously impairing the efficiency of the instrument.

Packing Piece.—Make up pieces of wood or iron, used to wedge up objects on the bed or face plate of a machine tool; chocking pieces serving as supports under anything; a general term for anything used as a *wedge, filler, or chock.*

Packing Ring.—A ring fitted around a piston to make it steam tight. For locomotives and other high speed engines, the Ramsbottom type of ring is usually employed, a narrow ring of steel or bronze, turned about one per cent larger than the bore of the cylinder the excess metal sawn out at the joint, and the rings sprung over the piston into suitable grooves around it.

Page, Charles Grafton.—Born 1812, died 1868. An American physicist and electrician, distinguished for his researches and experiments in electricity; discoverer of the magnetic sound known as the Page effect, or *magnetic tick.*

Page Effect.—A faint metallic tick which is sometimes heard at the moment when a bar is magnetized or demagnetized. It gets its name from its discoverer. It is thought to illustrate that magnetism is an action affecting the arrangement of the molecules of a substance.

Paint.—A thick liquid which is used to give substances a superficial coating. It is made of a dry coloring material mixed with a liquid vehicle. It is used largely to give decorative color effects to structures, also, to preserve them from the action of the atmosphere and other corroding agen-

cies. The dry coloring material of which the paint is made is called a pigment.

Paint Spraying Machine.—One by which paint is thrown by the force of air through a nozzle upon a surface, instead of being applied by hand.

Palette Combination Wire Gauge.—A form of wire gauge consisting of a pivoted cam mounted in a frame, so that the wire may be held for measurement between the cam and the frame.

Palladium.—A metal of the platinum group distinguished for its exceptional power of absorbing gases, or power of occlusion.

Palladium Alloys.—Non-magnetic alloys in which palladium is the chief ingredient, employed in the manufacture of non-magnetic watch springs.

Panel Board.—In a system of electric distribution, a switch-board carrying switches and safety fuses. Usually a small distributing switch-board.

Pancake Coil.—A flat coil of wire adjusted to the surface of an armature.

Paneled Wire.—For indoor work, electric conductors run along grooves, in suitably shaped mouldings or panels.

Panel Feeder.—A feeder leading to a bus bar connected with a switchboard panel.

Panel Fuse.—A safety fuse carried on a *panel board.*

Panel Pressure.—The electric pressure existing at a panel of a *switchboard.*

Panel Reflector.—A reflector in which the reflecting material is arranged in panels or strips.

Pan-telephone.—A highly sensitive microphone capable of reproducing sound vibrations at a great distance.

Pantograph Trolley.—A form of trolley employed in high speed electric traction. A broad contact shoe, formed of a conducting material which does not wear the wire is supported by jointed elbows resembling a pantograph carried on springs. The trolley is raised and lowered by compressed air.

Paper Cable.—An electric cable insulated by wrappings of specially prepared paper.

Paper Condenser.—A condenser having a dielectric composed of *insulated paper.*

Paper Filament.—An early type of incandescent lamp filament made of carbonized paper.

Paper Insulation.—An insulation often employed for electric light, power, and telephone cables, consisting of specially prepared tough paper, loosely laid on or crinkled, so as to form a dielectric of both paper and air. The paper covered conductor is encased in a lead sheathing, and so long as this sheathing remains intact good results are obtained. Paper and air form a better insulator than india rubber or any other of the usual insulating materials. Paper covered cables are especially suitable for use with alternating currents, because they can be readily constructed with a much lower electrostatic capacity than can be economically obtained with other materials.

Papier Maché.—A material made from paper pulp mixed with other substances. It is used for the mold in stereotyping, and in electrical work as an insulating material for low voltages, or as a secondary insulator to back up a primary insulator such as mica.

Parabolic Reflector.—A concave mirror having a surface such as would be generated by the revolution of the arc of a parabola. It reflects light in *parallel rays.*

Paraffin.—A colorless, or white, waxy substance obtained by dry distillation from wood, coal, peat, petroleum, etc., largely used in electrical work for its moisture proof and insulating properties.

Paraffined Wire.—An insulated electric wire provided with a final coating of paraffin.

Paraffining.—Applying a coating of paraffin for insulation purposes.

Paraffin Wax.—A white or yellowish waxy solid procured from the crude oil obtained in the distillation of paraffin shale or from the heavier portions of petroleum. It is not acted on by acids at ordinary temperatures nor by alkalies under any conditions. It is the chief substance for making candles and is important in electrical work as a non-conductor.

Paragrele.—A lightning rod device of doubtful utility, designed to attract hail

stones, and so prevent damage to growing crops.

Parallax.—An apparent displacement of an object caused by actual change in the position of the point of observation.

Parallax Error.—An error which may occur in the reading of an index or needle indication upon a scale, if the eye be not in exact relation to the pointer.

Parallel.—A line, which throughout its whole extent, is equally distant from another line.

Parallel Arc Circuit.—A parallel circuit.

Parallel Circuit.—An electric circuit in which all the positive poles, terminals, etc., in the circuit are connected to one conductor, and all the negative terminals to the other; a *multiple circuit.*

Parallel Connected Battery.—A voltaic battery in which the zinc or positive plates of the cells are joined together, and, likewise, the copper or negative plates, yielding, thereby, no greater electromotive force, but a current equal to the combined capacities of the plates.

Parallel Connected Condensers.—A method of connecting condensers so that their total capacity equals the sum of their individual capacities.

Parallel Connected Dynamos.—Two or more direct current dynamos joined up in parallel.

Parallel Connected Transformers.—Transformers in a system of electric distribution having all their primary coils connected across the mains in parallel, and incandescent lamps, or other apparatus connected in parallel with the secondary coils.

Parallel Connection.—A method of connecting up an electric system in which all the positive poles, or terminals, are joined to one conductor, and all the negative poles to the other; *multiple connection.*

Parallel Coupling.—The connection of alternators running in parallel.

Parallel Distribution.—A system of electric distribution in which the receptive devices, such as incandescent lamps, are connected in parallel between pairs of parallel mains.

Parallel Feeding.—Supplying electric current to a parallel connected circuit.

Parallel Forces.—In mechanics, forces which act in directions parallel with one another.

Parallelogram.—A figure whose opposite sides are parallel; the square and oblong are parallelograms; so also are other four sided figures whose angles are not right angles.

Parallelogram of Forces.—A method of finding the resultant of any two uniform forces, by drawing a parallelogram whose adjacent sides represent the two component forces, the concurrent diagonal of which represents the resultant.

Parallel Running of Alternators.—The joining up of two or more alternating current dynamos in parallel connection, when the machines agree in phase and frequency of alternation.

Parallel Series Circuit.—An electric circuit containing groups of series connected receptive devices, the groups being arranged in the circuit in parallel; a *multiple series circuit.*

Parallel Series Connection.—The arrangement of receptive devices, such as lamps, in an electric circuit in a number of series connected groups, these groups, in turn, being connected in parallel; *multiple series connection.*

Parallel System of Gas Lighting.—A system of lighting gas jets by electricity in which one terminal of the battery is connected through a spark coil to the gas pipe and the other to the insulated burner terminal. A grounded terminal on the burner is adjusted so as to make contact with the insulated terminal, and when that contact is broken, a spark is made which lights the jet.

Parallel Tree System.—In early installations of electric lamps a parallel system of distribution in which a pair of mains was extended through the district with branches reaching out in either direction from them, so that the plan of the system resembled a *tree with spreading branches.*

Parallel Winding.—A method of armature winding, usually known as *lap* winding, in which adjacent coils are connected in series instead of the connections progressing in a "wave" around and around the core. The lap winding is suitable for large machines. It is characterised by having as many circuits through the armature from positive to negative brushes, as the machine has poles, the current dividing equally between these parallel circuits.

Parallel Wire Stretcher.—A form of lineman's wire clamp for gripping a wire and bringing it to the proper tension.

Paramagnet.—A paramagnetic substance; a substance, such as iron, which readily becomes magnetic.

Paramagnetic. — Magnetic; having the property of being readily attracted by a magnet, as distinguished from *diamagnetic*.

Paramagnetism.—The magnetism possessed by paramagnetic bodies; *ferro-magnetism*.

Para Rubber.—The best grade of india rubber for electrical purposes, and the grade generally specified for insulation work. It is derived from the Amazon Valley in South America, and gets its name from the city of Para, in Brazil, from which it is exported.

Parasitic Currents.—Useless local currents that are liable to arise in the core of an armature and waste energy by generating heat. They are usually known as *eddy* or *Foucault* currents, and it is to obviate them that armature cores are laminated.

Parcel of Wire.—A term sometimes used in connection with a piece or length of wire submitted for testing.

Parchmentized Filament.—A variety of incandescent lamp filament made from cotton thread which is first subjected to a *parchmentizing process* by passing it slowly through a solution of sulphuric acid and water, and then carbonized.

Parchmentizing.—The process of preparing a cotton thread or a thread of cellulose for use as an incandescent lamp filament, by first passing it through a solution of sulphuric acid and water before carbonizing.

Partial Contact.—A contact between two electric circuits such as to produce a partial fault in the circuits.

Partial Disconnection.—A fault in the connection of an electric circuit which partially breaks the circuit; a *partial break*.

Partial Earth.—A partial fault in an electric circuit due to a partial earth connection.

Partial Fault.—Any fault in an electric circuit which interferes with the proper working of the circuit without causing its complete interruption.

Partially Overlapping Armature Winding.—A method of winding armatures, in which some of the coils are made to overlap one another, while others are laid on separately.

Partial Vacuum.—A vacuum in which a residue of air remains.

Particle.—A minute part or portion of matter; a very small substance; an atom; a jot; as, a particle of light.

Parting of Cable.—A breaking in two, as when a submarine or other cable completely gives way under heavy strain.

Partinium.—An alloy of aluminum and other metals used in motor car construction, for such pieces as cast gear cases and crank cases.

Party Line.—A telephone line connecting a central office with more than one station or subscriber, as distinguished from a *private line*. The party line is available for small private telephone systems, connecting a number of neighboring houses with one another or with stores or places of business.

Partz Gravity Cell.—A primary cell having electrodes of zinc and carbon in sulphate of magnesia and a chromic solution, the liquids being kept separate by their difference in weight.

Passive State.—A term applied to the condition of a substance which remains unattacked when exposed to the action of an acid which would ordinarily corrode it; as when cast iron is not acted on by strong nitric acid.

Paste Joint.—In an incandescent lamp, a method of joining the filament to the leading in wires by the use of a carbonaceous cement which is afterward carbonized by sending a strong current through it.

Pasting.—A process of preparing lead plates for storage cells, in which the grids are coated with lead oxide and sulphuric acid; the red oxide of lead, or *minium* being usually employed for the positive plates, and the yellow oxide, or *litharge,* for the negative plates.

Patch.—A small piece of material used to repair anything; as, a piece of metal to strengthen a weak place; in steam boiler repairs, if it be bolted or studded, it is called a *soft patch,* if riveted, a *hard patch.*

Patch Bolt.—A screw or bolt with a coned or countersunk head, used to attach patches to boilers, etc. The screw is put in by means of a wrench gripping a square projecting part beyond the chamfer.

Patch Piece.—In boiler making, a plate of wrought iron or steel and sometimes of cast iron, riveted or bolted to broken parts for purposes of repair. Broken castings are sometimes patched in this way in preference to replacing them with new. Boiler plates are often *patched,* and so is plated work generally, which has been injured by corrosion or accident.

Path of Magnetic Leakage.—The path followed by stray lines of magnetic force.

Patina.—A green semi-transparent crust consisting of basic copper carbonate which appears on the surface of copper and bronze when exposed for a long time to the air. The effect is obtained artificially by immersing copper articles in a bath of acetic acid.

Patrol Alarm Box.—A signal box from which an alarm may be sent by a police, or fire patrol.

Pavilion.—In wireless telegraphy, a fan shaped arrangement of wires supported on tall masts, and converging upon the receiving apparatus, sometimes employed for gathering the electric waves over an extended surface.

Pay As You Enter Car.—A model of electric street car construction introduced to simplify the loading and unloading of passengers and the collection of fares. The platforms are lengthened to allow of an entrance and an exit. The passenger enters at rear entrance, deposits his fare in the receiver, and alights from the front or from an exit passage way on the rear platform, the conductor remaining at all times upon the rear platform.

Paying Out.—In submarine cable laying, the regulated delivery of the cable into the water from the stern of the cable ship.

Paying Out Drum.—In submarine cable laying, a revolving sheave or drum over which the cable passes as it is paid out from the stern of the cable ship.

Paying Out Leg.—The side or leg of a loop of cable that is being paid out from a cable ship.

P. C.—Abbreviation for *primary current.*

P. D.—Abbreviation for *potential difference.*

Peaked Wave.—A pointed maximum value of an alternating current wave of alternation.

Peak Load.—In central station work, the maximum load which has to be carried by the machines at any time of day or night as shown by the highest point of the *load diagram curve.*

Pea Lamp.—A diminutive type of incandescent lamp.

Pearl Ash.—The salt which is obtained from the ashes of plants by washing and evaporation, or if refined, it is the *potassium carbonate* of commerce.

Pear Push.—A pear shaped wooden terminal of a pendant cord containing a push-button for making an electrical contact, a *pressel.*

Pear Tree Wood.—Wood of the pear tree, growing in temperate climates. The wood is used for making instruments; as, set squares, curves, and occasionally for pattern making. A cubic foot weighs 45 pounds.

Peat.—A substance of vegetable origin, of probable value in power production. It consists of roots and fibers in various stages of decomposition, and found, as a

kind of turf or bog, in low situations, where it is always more or less saturated with water. Peat next to the surface is less advanced in decomposition, is light, spongy and fibrous, of a yellow or light reddish brown color; lower down it is more compact, of a darker brown color, and in the lowest strata it is of a blackish brown, or almost a black color, of a pitchy or unctuous feel. Peat in its natural condition generally contains from 75 to 80 per cent of water. It sometimes amounts to 85 or 90 per cent in which case the peat is of the consistency of mire.

Pedestal of Armature.—A support for carrying the bearings of an armature.

Peg Circuit.—A circuit controlled by a *peg switch.*

Peg Switch.—A switch that is operated by the insertion or withdrawal of a peg; also called a *pin switch.*

Peg Switchboard.—A switchboard provided with peg switches.

Peltier Effect.—The effect discovered by Peltier, of heating or cooling the junction of two dissimilar metals, according as an electric current is sent through the junction in one direction or the opposite; the reverse of the *thermo-electric,* or Seebeck effect.

Peltier, Jean Charles Athanase.—Born 1785, died 1845. A French physicist and meteorologist; discoverer of several important electrical phenomena, especially the so called Peltier effect (1834).

Peltier's Cross.—A contact of two unlike metals at right angles for the purpose of exhibiting the Peltier effect.

Pelton Wheel.—An impulse water wheel, belonging to the class of wheels known as *hurdy gurdies,* suitable for working under extreme heads of water. The wheel is of small diameter, revolving on a horizontal shaft, the water being supplied through a nozzle in a needle like jet. The great feature of the Pelton wheel is the bucket which is divided midway by a tapered ridge, which prevents the accumulation of any "dead water," the stream splitting on the ridge and curving right around to right and left in each half bucket, thus providing the maximum force of reaction.

Pen Carriage.—In an electric chronograph, the device for carrying the pen or stylus which traces the record upon the paper strip.

Pencil Microphone.—An early form of microphone devised by Hughes, and usually called by his name. It consisted of a thin carbon pencil supported loosely between two blocks of carbon fixed to a sounding board. When connected with a battery and a telephone receiver, it served to greatly intensify sound. The present day, loose carbon contact transmitters are based upon the principle of Hughes' microphone.

Pendant Cord.—A flexible cord containing a pair of insulated conductors, employed for suspending incandescent lamps, or for making electrical connection with other movable electric devices.

Pendant Pull Switch.—A switch which is opened and closed by a pendant pull.

Pendant Socket.—A lamp socket for light electrolier or ceiling lamps, provided with a pendant or hanging chain for turning on or extinguishing the light.

Pendulum.—A body so suspended from a fixed point as to swing freely to and fro by the alternate action of gravity and momentum; as, the pendulum of a clock. A clock pendulum in which the effect of changes of temperature on the length of the rod is so counteracted, usually by the opposite expansion of different metals, that the distance of the center of oscillation from the center of suspension remains invariable; as, the mercurial compensation pendulum, in which the expansion of the rod is compensated by the opposite expansion of mercury in a jar constituting the bob and the gridiron pendulum, in which compensation is effected by the opposite expansion of sets of rods of different metals.

Pendulum Annunciator.—An annunciator in which the index consists of a pendulum or upright arm which is caused to swing by the electric current; a swinging annunciator.

Pendulum, Electric.—1. A pith ball suspended by a silk thread from an insulated support, for the purpose of illustrating electrical repulsion.

2. A pendulum operated by an electromagnet, and so adjusted as to open and close a circuit by its swing.

Pendulum Indicator.—An electric pendulum annunciator which finds its principal use in hotel offices.

Pendulum Motion.—In mechanics, the movement of a body so suspended from a fixed point as to swing freely to and fro by the alternate action of *gravity* and *momentum.*

Pendulum Myograph.—An electric pendulum for measuring the contraction and relaxation of muscular tissues.

Pendulum Selector.—An instrument for selective telephone signaling on party lines, in which a pendulum or elastic reed is caused to vibrate only by current impulses having a frequency corresponding to the rate of vibration of that particular reed, the reed at all of the stations being adjusted so as to have different rates of vibration.

Pendulum Signaler.—A pendulum which transmits signals by making and breaking an electric circuit by its swings.

Pen, Electric.—A stylus, operated by an electric motor, for making perforations in paper corresponding to a design or writing, so that the paper may afterwards be used as a stencil for manifold copying.

Penetrating Effects of Discharge.—A discharge of electricity under very high pressure has the power of piercing glass and other insulators. Although the dielectric strength of glass is very great, electricity from a powerful induction coil has pierced glass three inches thick. Two curious effects were observed by Lullin; when a piece of cardboard is perforated by a spark; 1, there is a slight burr raised on each side; 2, the hole is found to be nearer the negative point, if the two electrodes be not exactly opposite each other. A sheet of glass may be easily pierced by a spark from a battery of Leyden jars.

Penstock.—In hydraulics, the flume, conduit, or trough leading from the source of supply to a turbine or water wheel.

Pentad Atom.—An atom having the valency, or combining power of five units, *i. e.*, of five atoms of hydrogen.

Pentane Standard.—A standard of illumination employing a lamp with a specially constructed burner consuming a mixture of 7 parts of pentane gas and 20 parts of air at the rate of a half cubic foot per hour.

Pentode Working.—In synchronous multiplex telegraphy, the simultaneous transmission of five messages over the same wire.

Penumbra.—A region of partial and varying shadow surrounding the total shadow, or *umbra*, cast by an opaque body, when the source of light is a luminous body with greater or less area.

Percentage Conductivity of Wire.—1. The conductivity of a wire upon the basis of the conductivity of a standard copper wire of the same size.

2. The conductivity of a wire upon the basis of Matthiessen's meter-gram standard.

Perfect Linkage.—The linking together of lines of magnetic force and the conducting coils through which they pass without any magnetic leakage.

Perforated Armature.—1. An armature having a perforated core to admit of ventilation.

2. An armature having perforations in its core for the winding of the coils.

Perforated Core Discs.—Discs for building up a laminated armature core, having perforations to admit the windings.

Perforated Pulley.—In millwrighting, a wrought iron or steel pulley, which is honeycombed with numerous small holes perforated through the plate of which it is composed, and through which the air can escape, thus giving a belt closer adhesion.

Perforator.—A part of the apparatus employed in automatic telegraphy, which prepares the message for transmission by punching holes, corresponding to the signals of the Morse code, in a paper ribbon.

Perforator Mallet.—A mallet for striking the keys of a perforator which drive the punches through the perforator slip, thereby cutting out holes corresponding to the Morse code.

Perforator Slip.—A strip of specially prepared paper in which holes have been punched corresponding to the dots and dashes of the Morse code, for use in automatic telegraphy.

Period.—The time taken to execute a complete cycle of periodic motion.

Periodically Decreasing Discharge.—An oscillatory discharge in which the oscillations grow constantly feebler till they die away.

Periodic Alternating Electromotive Force.—An electromotive force constantly changing its direction in rapidly succeeding periods of alternation, giving rise to *alternating currents.*

Periodic Current.—An electric current resulting from periodic alternating electro-

motive forces; a current periodically changing in strength and direction; *alternating current.*

Periodic Discharge.—An *oscillatory* discharge. A series of rapid alternations of charge which are set up if the plates of a charged condenser be connected by a conductor of not too great resistance, the plates becoming alternately positively and negatively charged. In this way an alternating current exists of diminishing strength.

Periodic Governor.—A governor employed with an electric motor for automatically cutting off the current at regular intervals.

Periodicity.—A term sometimes used for the frequency of an alternating current. It is the number of *periods* or *double alternations made per second.*

Periodicity of Auroras and Magnetic Storms.—Periodical recurrences of auroras, frequently accompanied by increased magnetic variations and a maximum of *spots on the sun.*

Periodic Motion.—A movement which is repeated in definite regular intervals of time, like the swinging of a pendulum or the vibrations of an *alternating current wave.*

Period of Open Circuit Oscillation.—The time required for one complete to and fro motion of an oscillation set up in an open circuit by electric resonance.

Period of Simple Harmonic Motion.—The time required by a body performing harmonic motion to repeat its swing past a given point in the same direction.

Period of Vibration.—In vibrating motion, the time occupied by a complete cycle of vibration. As, for example, the time in seconds for an alternating current to pass through a complete cycle or curve is called the *period* of an alternating current, and the number of periods in a second is called its *frequency* or *periodicity.*

Periphery.—As applied to a wheel, disc, or cylinder, the surface of its circumference.

Periphery Speed.—The rapidity of motion of a point upon the periphery of a rotating wheel.

Periphery Velocity.—The rate of surface speed per minute of a rotating wheel, disc, or cylinder.

Peripolar Zone.—In electro-therapeutics, the parts of a patient's body just outside of the immediate region of the electrodes that are being applied to it.

Peristaltic.—A term applied by Lord Kelvin to the kind of electrostatic induction that takes place between conductors enclosed within the same insulation, as in a submarine cable.

Permanency.—The property possessed by electric conductors of retaining their conductivity unchanged for an indefinite time.

Permanent Currents.—1. In the Wheatstone automatic telegraph, electric currents continuously applied to the line while signaling.

2. Currents employed in double current telegraph working.

3. A constant current strength sometimes maintained on the line in telephone working.

Permanent Gas.—Since the year 1877, when Cailletet and Pictet succeeded in liquefying hydrogen and other gases, the term *permanent* as applied to a gas signifies that the gas is capable of being liquefied only with great difficulty, either by the use of a very low temperature, or an extremely high pressure, or by both means. So long as gases exist or act under conditions which are widely different from those required for liquefaction, they conform very nearly to certain simple laws which may be considered as rigorously applicable to ideal substances that may be called perfect or permanent gases.

Permanent Induced Charge.—A permanent electric charge produced in a body by induction.

Permanent Intensity of Magnetization.—The intensity of the magnetism permanently retained in magnetized steel.

Permanent Magnet.—A magnet consisting of hard steel which possesses coercive force, or retentivity, in a high degree, and is, therefore, said to retain its magnetism permanently; used in the construction of magneto generators.

Permanent Magnet Ammeter.—An ammeter employing a permanent magnet to produce its magnetic field.

Permanent Magnetism.—The magnetism permanently retained by magnetized steel.

Permanent Magnetization.—The magnetization of hard steel which results in permanent magnetism, as distinguished from the magnetization of soft iron.

Permanent Magnetomotive Force.—Magnetomotive force exhibited by a permanent magnet.

Permanent Signals.—In telegraphy, signals transmitted through recording instruments, leaving a permanent record for reference.

Permanent State.—The state of a telegraph line when a current of uniform strength exists throughout the line, as distinguished from the *variable* state.

Permanent Telegraph Line.—A telegraph line erected for permanent service, as distinguished from a temporary line.

Permeability.—The magnetic permeability. The ratio between the number of lines of force per unit area passing through a magnetizable substance, and the magnetizing force which produces them. In other words, it is the ratio of flux density to magnetizing force. Permeability is a measure of the ease with which magnetism passes through any substance. The permeability of good soft wrought iron is sometimes 3000 times that of air, varying with the quality of the iron.

The magnetic permeability decreases as the magnetization increases. When a piece of iron has been magnetized up to a certain intensity its substance shows a tendency to reach magnetic saturation. In good iron this is reached at about 125,000 lines of force to the square inch of area of cross section.

If B=the magnetic induction, and H the magnetizing force, the permeability μ is given the following equation:

$$\mu = \frac{B}{H}$$

For non-magnetic materials, B is very near unity, for iron, etc., its value varies greatly and depends on the magnetization, decreasing as the latter increases. According to Hopkinson the permeability for different values of B is as follows:

B	μ
5,000	3,000
10,000	2,000
15,000	526
20,000	30

Permeability Bridge.—An instrument, involving the principle of Wheatstone's bridge, designed for measuring magnetic permeability.

Permeability Curves.—Graphic curves showing the relation between magnetic density and permeability in magnetic substances.

Permeameter.—An apparatus for measuring magnetic permeability by the traction method, in which a spring balance indicates the pull required to detach the sample of iron which is being tested from the magnetic mass to which it is caused to adhere.

Permeance.—The reciprocal of magnetic reluctance, just as electric conductance is the reciprocal of electric resistance.

Permeation.—A term used in magnetism for the entrance of magnetic flux into the mass of a magnetizable substance.

Permissive Block System.—An electric railway block system in which more than one train may be admitted to a block under special circumstances.

Perpendicular.—1. At right angles to the plane of the horizon; vertical; upright.

2. In geometry, a line at right angles to a given line.

Persistence of Force.—A term sometimes used for *conservation of energy*, a law of physics that energy may be communicated from one body to another, or may be changed from one form to another, but cannot be created or destroyed.

Perviance.—Conductance to magnetic induction, as opposed to *diviance*.

Petrol.—The term *petrol*, as applied to automobile fuel, is in general use in England and upon the Continent. Petrol was a moderately heavy benzine, the first available fuel put on the French market, but the term has been extended to cover all light petroleum products, much in the same way as the American usage of the term *gasoline* has widened to include all the light volatile hydrocarbons known to refiners the world over as *benzine*.

TABLE OF CALORIFIC VALUES.

FUEL.	B. T. U. Per Pound	B. T. U. Per Cubic Feet
Petroleum (heavy crude oil), Penna.	20,737	...
Petroleum (light crude oil), W. Va.	18,404	...
Petroleum (heavy crude oil), W. Va.	18,232	...
Benzine	18,448	...
Gasoline	18,000—21,900	...
Gasoline Vapor	18,000—21,900	690
Acetylene	21,492	868

Petroleum.—Rock oil; a liquid, inflammable, bituminous substance exuding from the earth or collected on the surface of the water in wells and fountains in various parts of the world, or oozing from cavities in rocks; it is essentially composed of carbon and hydrogen.

Petticoat Insulator.—A name given to the common forms of line wire glass insulators which have one, two or three deep flanges or petticoats of glass around the base for the purpose of increasing the leakage path from the line to the pin. Porcelain insulators for high voltage transmission are also of the petticoat type.

Pewter.—An alloy usually consisting of tin and lead; a hard, tough, but easily fusible composition, originally consisting of tin with a little lead, but afterwards modified by the addition of copper, antimony or bismuth. Inferior sorts contain a large proportion of lead.

Phantom Circuits or Wires.—A name given to the extra transmission circuits established over a single wire in *multiplex telegraphy.*

Phase.—In wave, vibratory, and simple harmonic motion, the portion of one complete vibration, measured either in angle or in time, that any moving point has executed.

Phase Angle.—The angle expressing the phase relation in an alternating current.

Phase Detector.—A device for indicating the phase of an alternating current.

Phase Diagram.—A diagram which graphically represents the magnitude and relative phases of electric currents.

Phase Difference Measurer.—An instrument for measuring phase difference between alternating currents.

Phase Indicator.—Any device for indicating that two electric machines are in synchronism. The simplest form for low pressure machines consists of one or more incandescent lamps in series which are lighted and put out alternately as synchronism is approached. When the phase difference is zero the lamps will be brightest, when the difference is 180° the lamps will be dark; a *synchronizer.*

Phase Lag.—In an alternating current circuit, when the current reaches a maximum or zero value at a time *later* than the corresponding values of the pressure, the current is said to be out of phase with the E. M. F. and to *lag* behind the pressure.

Phase Lead.—In an alternating current circuit, when the current reaches a maximum or zero value at a time *earlier* than the corresponding values of the pressure, the current is said to be out of phase with the E. M. F. and to *lead* the pressure.

Phase Meter.—An electric measuring instrument for showing the phase-angle between the pressure and current or, preferably, the power factor of the same; *a phase angle* or *power factor meter.*

Phase Modification.—Producing a change in the phase of periodically alternating motion.

Phase Regulation.—The control and mutual adjustment of the phases of alternating currents or pressures.

Phase Splitter.—1. A device for producing two currents differing in phase to assist in starting a single phase induction motor.

2. Any device for changing single phase into polyphase currents.

Phase Splitting.—The process of changing a single phase alternating current into polyphase currents.

Phase Transformation.—The use of a transformer for changing a system of polyphase currents into another system differing in phase, or for transforming single phase into polyphase currents.

Phase Transformer.—A stationary transformer for converting an alternating current from one number of phases to another, and at the same time to produce step up or step down transformation.

Phase Windings.—The windings of an armature for the production of currents differing in phase.

Phasing Current.—An instantaneous current which passes through two alternators before they come into step when they are switched into parallel.

Phasing Transformer.—A transformer for changing the phase of electric currents; one that effects phase transformation.

Phelps' Stock Printer.—A system of printing telegraphy for transmitting news of stock transactions.

Phenomenon.—Any event or change observed as taking place in nature.

Phial.—A glass vessel or bottle; a broad, flat shallow cup or bowl; also spelled *vial.*

Phillips Code.—A telegraph code employed in the United States for press work.

Philosopher's Egg.—An ellipsoidal vacuum chamber containing two vertical electrodes, a discharge between which resembles a *luminous egg.*

Phonautograph.—A device for registering speech, in which a stylus mounted upon a diaphragm is caused to vibrate by the sound waves so as to transfer the spoken message by corresponding marks upon a rotating cylinder.

Phone.—1. A contraction commonly used for telephone.

2. A contraction for the act of telephoning.

3. A telephone message.

4. The receiver in phonoplex telegraphy.

Phonic Wheel.—In a synchronous multiplex telegraph system, a type wheel rotated by timed electric impulses transmitted over the line.

Phono-electric Wire.—A wire used for trolley lines and long telephone line spans. It is composed of 98.55% copper, 1.4% tin and .05% silicon. Its tensile strength is 40 to 45% greater than that of hard drawn copper, but its conductivity is only 40% that of pure copper.

Phonograph.—An apparatus, invented by Edison, by which permanent records of sound are impressed upon wax cylinders, and afterwards reproduced at will from the record.

Phonographic Record.—The sheet of tin foil or wax bearing the impression of the record made in a phonograph; *a phonogram.*

Phonophore.—A name given to a form of *harmonic telegraph.*

Phonoplex Receiver.—An instrument comprising an electromagnet and a disc resembling the diaphragm of a telephone receiver, so adjusted as to respond to pulsatory currents, but to remain unaffected by the regular Morse signals; the "phone" in phonoplex telegraphy.

Phonoplex Telegraphy.—A system of telegraphy in which pulsatory currents are superposed upon the regular Morse currents to operate a form of telephone receiver, and thus allow of *double transmission* without interference.

Phonoplex Transmission.—Telegraphic transmission employing pulsatory currents superposed upon regular Morse circuits.

Phonoscope.—An instrument for observing or exhibiting the motions or properties of sounding bodies.

Phonozenograph.—A device operating by a telephone in conjunction with a Wheatstone bridge for determining the point from which a sound comes.

Phosphor Bronze.—An alloy of copper, tin and two to five per cent of phosphorus, of a reddish brown color, which after annealing and tempering acquires great resiliency which makes it useful for springs. As an electric conductor, it is much stronger than pure copper, but of inferior conductivity. It is very durable and is often employed for parts of machinery exposed to shocks.

Phosphorescence.—A manifestation of luminescence, in which light, previously absorbed, is emitted by a body for a considerable time after the original source of light has ceased to act upon it. Either due to slow oxidation attended with light as in phosphorus, or by the molecular vibrations causing the emission of light after the source of light has been removed.

Phosphorescence, Electric.—Phosphorescence produced in a body by a static discharge of electricity.

Phosphorescent Glow.—Luminous phenomena following an electric discharge through *a vacuum tube.* Before exhaustion of the tube the sparks pass without any unusual effects. As the air is exhausted the sparks become less sharply defined, and widen out until the entire volume of the tube is occupied. At a certain degree of vacuum the light breaks into a set of patches of light of a cup-like form, which vibrate to and fro between darker spaces. Various effects may be obtained by introducing different gases, such as oxygen, nitrogen, etc., into the tube. In hydrogen gas, the tint of the electric discharge is bluish, except where the tube is narrow, where a crimson tint may be seen. The light of discharges in a vacuum is rich in those rays which produce phosphorescence and fluorescence.

Phosphorescent Lamp.—A lamp giving a phosphorescent light produced by an electrical discharge through a vacuum.

Phosphoroscope.—An instrument for determining the phosphorescence or fluorescence of a substance.

Phosphor Tin.—Tin with which phosphorus has been combined, rendering it suitable for making phosphor bronze.

Phosphorus.—An elementary substance, of a yellowish color, and semi-transparent, resembling fine wax. It burns in common air with great rapidity, and in oxygen gas with the greatest vehemence. Even at the common temperature, it combines with oxygen, undergoing a slow combustion, and emitting a luminous vapor.

Phot.—A unit of illumination equal to a lux for a second of time; *a lux second.*

Photo-chemical Effects.—Chemical changes produced by the action of light.

Photo-chemical Spectrum.—The spectrum of the ultra-violet rays of light which, though invisible to the eye, accompany luminous radiation and may be detected by photographic means.

Photo-chemistry.—That branch of chemistry which treats of the action of light in producing chemical effects.

Photo-chronograph.—An electric chronograph provided with a photographic apparatus for taking instantaneous pictures of a moving object, such as a heavenly body, at regular intervals of time.

Photo-electric Alarm.—An alarm operated by a selenium cell by which a bell is rung when the cell is exposed to the action of light.

Photo-electric Cell.—A name sometimes given to the *selenium* cell, a device employed for the transmission of speech by the action of light, depending upon the property of selenium of changing its electrical resistance under the influence of light.

Photo-electricity.—Electrical properties developed by the action of light.

Photo-electromotive Force.—Electromotive force generated by the action of light.

Photo-engraving.—A name applied to each of many processes, in which the action of light on a sensitized surface is made to change the nature or condition of the substance of the plate or its coating, so that it may be made to afford a printing surface corresponding to the original from which the photographic image is derived.

Photographic Meter.—An electric meter employing photography to obtain its record.

Photometer.—An instrument for measuring the intensity of light, and, especially, to compare the relative illuminating powers of different sources of light.

Photometer Bar.—A horizontal bar provided with a graduated scale, and used in a photometer for sliding the screen between the two lights whose relative intensities are to be compared.

Photometer Box.—A box employed in certain types of photometers to contain the photometer screen.

Photometer Screen.—A paper disc, often containing a grease spot in the center, placed between the two lights to be compared by a photometer, and adjusted along a graduated scale; a *photometer disc.*

Photometric Unit.—A unit of light measurement, such as the *lumen hour* for quantity of light; the *lumen* for flux of light; the *candle* or *hefner* for intensity of light; the *candle per sq. cm.*, or *sq. ft.* for brightness; and the *lux* for illumination.

Photo-micrography.—The act of photographing microscopic objects which have first been enlarged by the microscope.

Photo-micrography, Electric.—The use of the electric light in photo-micrography.

Photophone.—An instrument for transmitting sounds along a beam of light reflected between mirrors, and converging upon a selenium cell. The reflecting mirror is thrown into vibrations by the sound waves, and the beam of light consequently falls with varying intensity upon a receiver of selenium connected in circuit with a small battery and a telephone receiver in which the sounds are reproduced by the variations of the current. Tellurium possesses similar properties and carbon also is sensitive to light.

Photophore.—A form of endoscope employing a small incandescent lamp for examining the internal cavities of the human body.

Photosphere.—The luminous envelope of incandescent matter surrounding the sun.

Photo-telegraphy.—Telegraphic transmission by means of light, as with a heliograph or a photophone.

Photo-voltaic Effect.—A change in the electric resistance of a substance, especially of selenium, when exposed to light.

Physical.—Relating to nature and the operation of natural law.

Physical Change.—Any change occurring in matter without altering its chemical constitution, as distinguished from *chemical change.*

Physical Law.—A law according to which a constant relation exists between certain physical quantities; a law of physical phenomena; *a natural law.*

Physical Tests.—Experiments conducted with specimens of materials, to determine their inherent properties, as tenacity, elasticity, etc., by the aid of mechanical combinations of levers and weights to apply the stresses in the desired manner.

Physics.—A branch of natural science concerned with many natural phenomena and their laws, including sound, light, heat, magnetism and electricity.

Physiology.—The science concerned with the laws and phenomena of living nature.

Piano, Electric.—A piano, in which electric currents are closed by fingering the keys, so that electromagnets are caused to operate the hammers upon the strings.

Piano Wire.—Also known as *music wire*; a remarkably fine and strong steel wire, intended for use in musical instruments, but much employed in the mechanical arts for measuring purposes, making small spiral springs, etc.

Picking Up Gear.—In submarine cable operations, the apparatus for bringing a cable to the surface.

Pickle.—To steep in an acid bath, for the purpose of removing impurities; as, in the following:

1. In boilermaking, the plates are steeped *on edge* for a period of six hours, in racks within a wooden bath, containing a 5% solution of *hydrochloric acid* in fresh water. This loosens the mill scale, which is removed by the aid of wire brooms, mechanical brushes and a plentiful supply of water. The cleaned plates are immersed in an alkaline bath of weak quicklime and water, to neutralise remaining acid, and finally washed in fresh water.

2. In iron founding, the castings are placed on racks, and have a 25% solution of *sulphuric acid* poured over them, by means of a ladle, the acid being collected and used over again. After standing to drip all night, the castings are washed down with a hose and brooms, remaining sand being removed by wire brushes and old files. A better method is to steep for two or three hours in a wooden vat containing ten per cent solution of *hydrofluoric acid*, which attacks scale and sand, but not iron. A vat may be used three or four times with the same acid.

Pickling Solution.—1. In electroplating, an acid solution for cleansing the surface of metallic objects preparatory to plating; the *pickle.*

2. A solution of dilute sulphuric acid for immersing steel and iron to remove scale and oxide before galvanizing.

Piece Number.—A number given to a pattern or a part of a machine to be used in case of repairs or duplication.

Piece of Wire.—A continuous length of wire free from joints or splices.

Pierced Armature.—A dynamo or motor armature provided with openings or slots for the introduction of the coils; *a perforated* or *slotted armature.*

Piezo-electricity.—Electricity produced by pressure, such as the electric polarity sometimes seen in a crystalline substance. It was discovered by Haüy, that a crystal of calcspar pressed between a man's dry fingers, so as to compress it along the blunt edges of the crystal, became electrical, and remained in this condition for several days. Mica, topaz and fluorspar are said to possess a similar property. Opposite kinds of electricity are produced by pressure on a crystal tourmaline at the opposite ends, and also on other crystals which possess a skew-symmetry or hemihedry in their structure.

Piezometer.—An instrument to measure flowing water. If a vertical or oblique tube be inserted into a pipe containing water under pressure, the water will rise in the former, and the vertical height which it reaches will be the head producing the

pressure at the point where the tube is attached. If the water in the piezometer falls below its proper level, it shows that the pressure in the main pipe has been reduced by an obstruction between the piezometer and the source of water supply. If the water rises above its proper level, the pressure there has been increased by an obstruction beyond the piezometer.

Pig Iron.—Iron refined from the ore in a blast furnace, and run into gridiron shaped moulds in the open air, where it takes the form of semi-cylindrical bars attached at right angles to a longitudinal bar, thus bearing a resemblance to a sow and pigs.

Pig Lead.—Lead in 300 pound bars or moulds as it comes from the reduction furnace; the commercial form in which it is sold.

Pike Pole.—A long pole, twelve or sixteen feet in length and tipped with an iron spike, for use in raising telegraph poles.

Pile.—A voltaic battery consisting, usually, of super-imposed plates; *the voltaic pile.*

Pilot Brush.—An additional commutator brush used for testing the electromotive force derived from the different commutator segments.

Pilot House Controlling Gear.—The appliances in a ship's pilot house for controlling the searchlight.

Pilot Lamp.—1. In a central power station, an incandescent lamp placed upon a dynamo, and connected across its terminals to show the pressure of the terminals by the brightness of its light.

2. In a lamp signal telephone switchboard, a specially conspicuous lamp connected with a group of line lamps in such a way that it remains lighted as long as any one of the lamps in the group is lighted.

Pilot Motor.—A small motor designed to start and control a large motor.

Pilot Transformer.—A small transformer set at any point in an alternating current system, in order to indicate to the central station the pressure at that point.

Pilot Valve.—A small valve fitted to larger valves on a main steam pipe, used to equalize pressures before opening or closing or to free the piping of pressure if necessary. Also called *by-pass valve.*

Pilot Wires.—In an electric lighting or power system, small wires connecting distant points in the mains with a voltmeter at the central station, in order that the pressure at those points may be watched.

Pincers.—An instrument having two handles and two opposing curved jaws, working upon a pivot, thus belonging to the same category of grasping implements, as *tongs*, *pliers*, and the like.

Pine.—A member of the pine family of trees, with evergreen, needle shaped leaves, distributed widely and plentifully through the Northern Hemisphere. The name is also given to many of the woods obtained from these trees, others being known as *fir* and *deal.*

Pinion.—A small cog wheel in gear with a larger one, either singly or in a train, a small gear wheel meshing with a rack.

Pin Plug.—A slender metal plug designed to make an electrical connection when inserted between two contact blocks.

Pins.—In pole line construction, wooden pegs with threads cut to fit the glass line insulators.

Pipe Conduit.—A conduit for *underground* wiring, consisting of properly prepared metal piping.

Pipe Fittings.—Connections, appliances, and adjuncts designed to be used in connection with iron pipes, such as *elbows* and *bends* to alter the direction of a pipe; *tees* and *crosses* to connect a branch with a main; *plugs* to close an end; *bushings*, *diminishers* or *reducing sockets* to couple two pipes of different dimensions, etc.

Pipe Pole.—A pole for overhead wires, consisting of jointed metal pipes or tubes.

Pipe Threads.—Screw threads employed in connection with wrought iron pipe. The standard thread is the V, with an angle of 60° between its sides, slightly rounded at top and bottom, and having a taper.

Pipe Tongs.—In pipe and steam fitting, a hand tool for gripping pieces or lengths of pipes.

Pipette.—A small graduated glass tube for transferring measured quantities of liquids from one vessel to another.

Pipe Vise.—A gripping appliance for holding pipes while being threaded or cut, having two V shaped serrated jaws sliding within each other, the grip being applied or released by means of a screw and toggle.

Piston.—A device for receiving the pressure of, or operating upon, a fluid in a cylinder or tube. It usually consists of a short cylinder, fitting within a cylindrical vessel, along which it moves back and forth. It is used in *steam engines* to receive motion from the steam, and in *pumps* to transmit motion to a fluid. It is the essential part of a reciprocating engine; a metal disc working in the cylinder, under the pressure of steam, and connected by means of a linkage of rods with the cranked rotating shaft, whereby the power is usefully applied. In *locomotives*, the piston is either solid, with Ramsbottom or snap rings fitted into grooves in its circumference,or else is built up with metallic packing rings, retained in place by a plate or ring. In such cases, the body of the piston is termed the *head*, any solid ring used to separate the split packing rings is the *bull ring*, while the retaining plate or ring is known as the follower.

Piston Manometer.—A manometer employing hydraulic pressure for compressing gases.

Piston Speed.—An engineering expression, signifying the total distance traversed by the piston of an engine, in one minute, rather than the actual velocity at any given instant of time. Thus, an engine whose cranks have 24 inches throw, revolving 126 times per minute, is said to have a piston speed of 504 feet per minute.

The result is obtained by the use of the following formula:

$$\text{Piston Speed} = \frac{2 \times \text{stroke in inches} \times \text{revolutions per minute}}{12}$$

substituting:

$$\frac{2 \times 24 \times 126}{12} = 504.$$

Pitch.—1. The vibration frequency of a musical note.

2. The vertical distance between two threads of a screw measured parallel to the axis.

3. Center to center distance between windings on a dynamo armature.

Pitchblende.—A mineral substance from which the element *radium* is derived by chemical separation, together with three other radio-active substances, viz.: uranium, polonium, and actinium.

Pitch Line.—A circle drawn through the middle of the length of the conductors wound upon an armature for the purpose of measuring the pitch of the windings.

Pitch of Poles.—In an alternator, the distance between the center of one pole piece to the center of the opposite pole piece.

Pitch of Winding.—1. In armature winding, a term denoting the *spacing* of the winding or the distance from one element to the next similar element in the succession. The *pitch* is usually expressed in terms of the number of conductors spanned over, though sometimes in terms of the number of loops of conductors or of slots passed over.

2. In an alternating current dynamo, the distance measured upon the pitch line between successive positive and negative poles.

Pith.—A light spongy cellular tissue which occupies the center of the stem in certain plants.

Pith Ball Electroscope.—An instrument consisting of a pair of pith balls suspended by cotton threads from an insulated conductor; when approached by a rubbed glass rod the balls fly apart, thus exhibiting the repulsion existing between similarly electrified bodies.

Pith Balls.—Small pellets cut from pith for use in experiments in static electricity with the pith ball electroscope.

Pitot Tube.—In hydraulics, a bent tube used to determine the velocity of running water, by placing the curved end under water, and observing the height to which the fluid rises in the tube; a kind of current meter.

Pitting.—In a steam boiler, a form of corrosion resulting in rows of minute holes or pits like pock marks. Pitting is most capricious in the location of its attack; it may be described as a series of holes often running into each other in lines and patches, eaten into the surface of the iron to a depth sometimes of one quarter of an inch. Pitting is a dangerous form of corrosion, and the dangers are increased when its existence is hidden beneath a coating of scale.

Pivotal Trolley.—A trolley base pivoted so that the trolley pole may readily be turned about to reverse the direction of the car.

Pivot Suspension.—A method of supporting the indicating needle of an electric measuring instrument in which the needle has a jewel at its center resting upon a sharp pivot, as distinguished from *fiber suspension*.

Plaited Accumulator.—A secondary or storage cell having grids consisting of lead strips plaited together.

Plan.—A drawing of a building or machine, done in a manner resembling a map; that is, as viewed from above; a representation of a horizontal plane of anything; a diagram.

Plane Angle.—An angle included between two lines in the same plane.

Plane of Polarization.—In plane polarized light, the plane perpendicular to the direction of the vibration of the light waves.

Plane Vector.—A quantity possessing both magnitude and direction in a single plane.

Planimeter.—An instrument used for measuring *areas*, as in indicator diagrams. It consists of two hinged levers, with points at the ends; one of which is secured to the paper, while the other, having at-attached to it a graduated wheel, is traced around the outline of the figure; the circuit being completed, the area is read from a graduated wheel, a vernier being provided so the area may be read to three decimal places. For a diagram, the area is divided by the length, which gives the average height or mean pressure.

Planimetry.—That branch of geometry which deals with the measurement of plane surfaces; the mensuration of areas, as distinct from *longimetry*, which deals with lengths of lines, or *stereometry*, which measures solid contents.

Plano-concave.—Having one surface flat and the opposite surface concave, especially as applied to a lens.

Plano-convex.—Having one surface flat and the opposite surface convex, especially as applied to a lens.

Plant.—The collection of machines and appliances, grouped together in any particular workshop, factory or building. An assemblage of machinery gathered together for one common end, or for the business of an individual, firm or corporation.

Plant, Electric.—The establishment, including all the machinery, apparatus and appliances for generating and distributing electrical energy.

Planté Cell.—An efficient form of storage cell named after its inventor; it is composed of large sheets of lead, separated by non-conducting material and rolled together, dipped in dilute sulphuric acid, and "formed" by charging with electric currents.

Plant Electricity.—Electricity exhibited in vegetable life; such as differences of potential existing in various parts of a tree.

Planté, Raimond Louis.—Born 1832, died 1899; a French electrician, inventor of a type of storage battery (1859).

Plaster.—1. A composition made of varying proportions of lime, sand and water, together with hair or other binding material. Used as a coating for walls, ceilings and partitions, being usually laid on *laths* and *furrings*.

2. Gypsum or plaster of Paris, as used for the ornamental or intricate parts of a plasterer's work.

Plastic Metal.—In metals, a white alloy having a low coefficient of friction and anti-corrosive properties, which adapt it for high speed bearings and for use under water. It contracts very little in cooling and fuses at a low temperature, and is used for fan bearings, locomotive axle boxes, glands, and for coating propeller blades.

Plastic Rail Bond.—In an electric railroad track, a bond between rail ends composed of a conducting compound which is applied when in a plastic state.

Plate Condenser.—A form of condenser for experimental purposes first devised by Aepinus and often called Aepinus condenser. It consists of two brass discs, one joined to a battery and the other to earth and separated by a glass plate. The inductive action of electricity across the plate causes an accumulation of electric charge on the positive disc. This device was formerly called an *accumulator*.

Plated.—Covered with a coating of metal as by electroplating.

Platform Controller.—The controller or switch placed upon the platform of a trolley car for the purpose of governing the movements of the car.

Platform Coupling.—A coupling for electric cars placed upon the car platform.

Plating.—1. The process of covering an object with a coating of metal, as in electroplating.

2. The art of coating stronger or baser metals with a film of a more valuable one, such as silver, gold, or nickel; either by electro deposition or otherwise.

Plating Balance.—A balance from which an article to be electroplated is suspended, so that when the article accumulates deposited metal up to a certain weight the balance tips and automatically stops the operation.

Plating Bath.—In electroplating, the acid solution, containing a salt of the metal to be deposited, held in a vat or trough which is fitted with terminals for the passage of an electric current through the solution. The action of electrolysis in this liquid causes metal to be freed from the anode and deposited upon the cathode which is the object to be plated.

Plating Dynamo.—A dynamo which supplies the electric current for electroplating.

Platinizing.—To coat a surface with finely divided platinum to provide a conducting surface; also *platinating* and *platining*.

Platinoid.—An alloy of copper, zinc, nickel and tungsten, having a temperature coefficient less than half that of German silver, often employed for resistance wires in resistance boxes. The addition of tungsten imparts greater density, and when polished the alloy has the appearance of silver. The resistance of platinoid ranges from about thirty to thirty-six microhms between the opposite faces of a cubic centermeter of the alloy, this being about one and one-half times the resistance of German silver.

Platinum.—A somewhat rare, silvery white metal, specific gravity 21.5, nearly the heaviest known, while it melts at about 3650° Fahr. Platinum is very ductile, is not dissolved by any acid, and is very difficult to oxidize. Its coefficient of expansion is practically the same as that of glass, hence it is used for the little connecting wires through the top of an incandescent lamp, leading the current from the contact pieces to the filament.

Platinum Black.—A dull black powder of finely divided platinum having in a high degree the power of absorbing oxygen.

Platinum Fuse.—A slender strip or wire of platinum used for firing a blast when heated to incandescence by an electric current.

Platinum Lamp.—An incandescent lamp having a platinum filament.

Platinum Plating.—Depositing a coating of platinum upon an object by electroplating.

Platinum Silver.—An alloy composed of one-third platinum and two-thirds silver, possessing high specific resistance.

Platinum Standard Light.—A standard of light proposed by Violle; being that which is emitted by a square centimeter of melted platinum at the temperature of solidification or at its melting point; the *violle*.

Platinum Voltameter. — A voltameter having electrodes of platinum in dilute sulphuric acid.

Platymeter.—An instrument, consisting essentially of a pair of cylindrical condensers with their inner coatings connected, for the purpose of measuring the capacity of condensers, or the specific inductive capacity of *dielectrics*.

Play.—A shop term for the amount of slack or looseness of fit between two pieces; the movement of one piece within another.

Plenum.—Any condition of fullness; a pressure of air, the opposite to vacuum. The *plenum method of ventilation* is a system for ventilating buildings by forcing in fresh air, the plenum or fullness created by its incoming, causing an outward flow of foul air.

Pliers.—Pinching tools, usually of small size and operated in one hand. They are used for manipulating wire or small objects, the nose or points being variously shaped for different purposes. The gripping points are more or less straight instead of being curved like *pincers*.

Plow.—In a conduit trolley system, the contact that is pushed along the underground trolley wire in the conduit for the purpose of deriving current for the car motors.

Plow, Electric.—A plow driven by electricity, used in agricultural operations on a large scale.

Plow Steel Wire.—Denotes a very high quality of wire originally used in the manufacture of steel rope, sometimes used for electric conductors.

Plücker Tube.—A form of vacuum tube specially designed to exhibit the stratifica-

tion of luminous rays, and the effects produced in the neighborhood of the negative electrode.

Plug.—1. A terminal, consisting of a metal tip and sleeve, insulated from each other, and connected to a flexible cord, for inserting into a spring jack in a telephone switchboard, and making the desired connection.

2. A metal key with insulated handle for inserting between contact blocks to complete a circuit, as in a resistance box.

3. A general term for a piece of any suitable material or form used to fill up a hole, the object usually being to prevent leaks.

Plug Cut Out.—A form of safety fuse block provided with a fuse plug.

Plugging.—Making a connection by inserting a plug, as in a telephone switchboard, or resistance box.

Plug Hole.—The hole in a switchboard for inserting a plug.

Plug Key.—A plug resembling a *key*.

Plug Resistances.—The resistance coils of a resistance box provided with contacts and plugs.

Plug Rheostat.—A resistance box in which the coils terminate in brass blocks which are reamed out to fit the shape of brass plugs with insulated handles. By inserting or withdrawing the plugs the resistances can be varied.

Plug Sleeve.—A tube of brass which encases the tip conductor of a telephone switchboard plug, and forms the second contact part.

Plug Switch.—A switch containing contact blocks separated from each other by just sufficient space to admit the plugs which complete the circuits.

Plug Switchboard.—A switchboard, such as a telephone switchboard, which makes its connections by the insertion of plugs. It consists of two distinct parts: 1, a series of upright panels carrying drop shutters and round apertures under the annunciator numbers, and, 2, a horizontal board or table, upon which appear a number of upright instruments, and in front of them a row of short levers. The panel apparatus thus consists of a number of small instruments such as are used on a hotel annunciator, which are known as "drops," and of another series of instruments, fixed behind the round holes on the front of the panel, which are called "jacks," or spring jacks. The upright instruments, that stand in rows below the panel-boards, are the "plugs"; and each of them is secured at the end of a flexible cord, passing through a hole in the switchboard table, attached at the back of the board, and held in place by pulley weights. The object of these plugs is to close the circuits between any two subscribers' lines, one of a given pair being inserted in the "jack" corresponding to the calling station, and another in that corresponding to the called station, connection being made between the two lines by means of the flexible conducting cords. A row of small levers at the front of the table constitutes the operator's "listening and ringing keys."

Plumbago.—Graphite or "blacklead"; used for crucibles and lubricating and also to coat non-conducting surfaces as gutta-percha. It is the composition with which the interior of pencils is filled.

Plumbing.—The art of working in lead, from the Latin, *plumbum*, lead. The work of the plumber lies chiefly in manipulating leaden sheets and pipes to various desired forms, but also includes the use of other materials, such as brass, iron or stoneware, in connection with water supply, baths, drainage, heating, ventilation, and sanitary arrangements of houses and buildings generally.

Plumb Line.—1. A line having a weight attached to its end; used to determine a perpendicular; a plummet.

2. A line perpendicular to the plane of the horizon; a line directed to the center of gravity in the earth.

Plunge Battery.—A primary battery in which the plates are so mounted upon a supporting bar that they can be lifted out of the electrolyte when not in use, and kept from wasting in the solution.

Plunger Door Contact.—A form of door contact in which a small plunger is forced by the closing door against a spring which closes an electric circuit and rings a bell.

Plunger Floor Contact.—An electric floor contact, operating on the principle of a plunger, and pushed by the foot.

Plunger Pump.—A reciprocating pump for working against comparatively high pressures, the *plunger* or *ram* being a solid cylindrical piece which is moved in and out of the pump chamber, its displacement at each stroke theoretically corresponding to the amount of liquid drawn into the pump and then expelled.

Plunger Switch.—A form of circuit breaker employed in high tension work. It

consists of a metal plug drawn in and out of a split tube by a lever mechanism while immersed in oil.

Plus Charge.—A *positive* charge. The kind of electric charge which is developed on glass by rubbing it with silk, as distinguished from a *minus* or negative charge such as is produced on resinous bodies by friction with flannel or fur.

Plus Pole. — The *positive* pole of a magnet. It is the pole which, if the magnet were suspended, would tend to point to the north. It is also called the *north, north-seeking, N, marked, blue,* and *boreal* pole.

Pneumatic.—Of or pertaining to air, gases, elastic fluids, etc. The term is generally restricted to matters connected with the nature or use of air, either under a partial vacuum or under pressure.

Pneumatic Battery.—A form of bichromate primary battery arranged to permit a jet of air to be blown through the electrolyte to aid in its diffusion and depolarization.

Pneumatic Perforator.—In automatic telegraphy, a perforator operated by compressed air.

Pneumatic Rodding.—A method of passing a wire through a conduit duct by applying air suction at the farther end, which draws a wooden cylinder or "dart" through the duct followed by the wire which is attached to it.

Pocket Galvanometer.—A galvanometer of convenient size to carry in the pocket.

Pocket Gauge, Electric. — A pocket galvanometer suitable for approximate measurements.

Pocket Relay.—A small sized telegraphic relay.

Pockets.—Spaces left in walls, ceilings, etc., to permit electrical connections to be made in a system of inside wiring.

Poggendorff Cell.—A bichromate cell first invented by Poggendorff. The electrolyte consists of dilute sulphuric acid to which has been added bichromate of potash to prevent polarization, the bichromate combining with the hydrogen as it is liberated from the sulphuric acid. The elements are plates of zinc and carbon, there being usually three plates of zinc and four of carbon to each cell. Cells of this type are usually arranged as a *plunge battery*, the cells being connected in series, and the plates suspended from a cross bar so that by a windlass arrangement, all the plates can be raised out of the solution when not in use.

Poggendorff, Johann Christian.—Born 1796, died 1877. A German physicist, distinguished for his investigations in electricity and magnetism; inventor of the first serviceable device for measuring electrical resistance (1841).

Point Discharge.—The discharge of static electricity from the tip of a pointed conductor which takes place when electricity of high potential accumulates at such a point, and by electrifying the surrounding air causes an escape of electricity by means of the charged air particles; *convective* discharge.

Pointer.—A needle or hand on a dial; a traveling or stationary index on a scale; an indicator to show direction or the like.

Pointer Telegraphy.—A system of telegraphy employing a needle or dial instrument at the receiving end. A code of movements of an index or pointer swinging over the face of the dial to the right and left comprise the letters of the alphabet.

Point of Ignition.—The moment at which the mixture in a gas engine cylinder is ignited, and which corresponds to a certain point in the cycle of operations, should be neither too early nor too late relatively to the ending of the compression and the beginning of the power strokes.

When the moment of ignition occurs too early, the maximum pressure of the explosion is reached before the end of the compression stroke, thus retarding the motion of the piston, increasing the friction on the crank pin, and consequently reducing the brake horse power. When the moment of ignition occurs too late, the mean effective pressure is reduced, and consequently the brake horse power also.

The highest efficiency is obtained by adjusting the point of ignition to suit the amount of compression, and the speed of the engine. As an interval of time, no matter how short, must elapse between the moment of ignition and the moment of maximum pressure in order to prevent the delivery of a dead blow on the piston, the moment of ignition should occur immediately after the crank passes its inner dead center at the end of the compression stroke.

Points of Compass.—The 32 points or rhumbs into which the compass card of the mariner's compass is divided, corresponding to supposed divisions of the horizon, of

which North, South, East and West are called the *cardinal points.*

Points of Lightning Rods.—Tips of copper forming the upper extremity of lightning rods.

Polar.—1. Pertaining to magnetic poles.
2. In geometry, proceeding from a fixed point of radiation.
3. In geography, of or pertaining to either of the poles of the earth; whether the geographical or magnetic poles.

Polar Bore.—The hollow space between the pole pieces of a dynamo within which the armature rotates.

Polar Duplex Telegraphy.—A differential duplex system of telegraphy, employing a polarized relay at the receiving station operated by signals given by reversing the current in the circuit by means of a *pole changer* at the sending station.

Polariscope.—An optical instrument for examining substances in polarized light; it is employed to identify minerals, precious stones, or to investigate rock structures.

Polarity.—1. The property of having opposite poles, or of having physical properties in opposition or contrast.
2. The possession of magnetic poles.
3. The quality or property of a magnetizable body of being attracted by one pole and repelled within the other, when brought within a magnetic field.

Polarity Indicator.—Any device for indicating the presence and direction of *magnetic flux,* also called *pole indicator.*

Polarity of Electromagnets.—If a wire be wound around a magnet in a right handed helix, the end at which the current flows into the helix is the south pole. If the wire be wound around an ordinary screw, and the current flows around the helix in the direction from the head of the screw to the point, the head of the screw is the south pole.

Polarization.—1. In a *primary cell,* the effect of increasing the internal resistance and diminishing the current strength, produced by the accumulation of hydrogen bubbles on the negative plate.
2. The condition of a *dielectric* when subjected to the strain of two adjacent opposite charges of electricity, as in a condenser.
3. In an *electrolyte* undergoing decomposition, the arrangement of the molecules by the electric current so that all the positive poles face the negative plate and all the negative poles face the positive plate.
4. In a magnet, the state of its molecules when permanent magnetism has been acquired; *magnetic polarization.*

Polarization Current.—In electro-therapeutics, a constant current which produces a condition of electrotonus in a nerve through which it passes.

Polarization Fault Current.—A counter current set up at a break in a submarine cable by the action of a testing or other current.

Polarization of Armature.—The result of the rotation of a dynamo armature is to produce a number of reactions between its windings and the magnetic field, with the result that the armature itself becomes a magnet, being constantly polarized at certain definite points in its path of rotation.

According to the accepted rule of magnetic induction, the tendency is to produce poles in the armature at right angles to the lines of force, but since the neutral points, theoretically situated on the same diameter, are points of contact between the brushes and the commutator, where the current leaves and re-enters the winding of the armature, it will be found that the armature is really transformed into two separate adjacent magnets, having two north and two south poles, on either side of the diameter of commutation. These double poles, practically operating as a single pole, at the two extremities of the given diameter, act to produce the great distortion of the lines of magnetic force, which follow the rotation of the armature.

Polarization of Dry Cells.—The generation of current in dry cells produces a condition known as "polarization," or the collection of hydrogen on the electrode attached to the positive lead wire. This condition may be remedied, that is, the cell may be "depolarized," only by leaving it for a period on open circuit, or disconnected. A polarized cell will show a low current register on the ammeter, but may be restored more or less after resting.

Polarization of Light.—The effect produced upon a ray of light when reflected from a surface or transmitted through certain crystalline media, such that its vibrations exhibit different properties in different directions at right angles to the direction of propagation.

Polarization Photometer.—A photometer in which the light of the more intense of the two sources under comparison is polarized.

Polarized Annunciator.—An annunciator, or indicator, operated by an electromagnet having a permanently magnetized armature.

Polarized Armature.—A steel armature for an electromagnet in a polarized telegraphic relay, being itself a permanent magnet, or having its magnetism maintained by a permanent magnet.

Polarized Call Bell.—An electric bell operated by an electromagnet having a polarized, or permanently magnetized armature.

Polarized Cell.—A primary cell which has become inactive from polarization.

Polarized Ink Writer.—In telegraphy, an ink recording instrument operated by an electromagnet having a permanently magnetized armature.

Polarized Radiation.—The effect, similar to the polarization of light, produced upon heat and other radiations by reflection and refraction.

Polarized Relay.—In telegraphy, a relay provided with a permanently magnetized steel armature which responds at a distant station to the action of a *pole changer* at the home station, being attracted by the electromagnet when the current flows in one direction, and repelled when the current is reversed; *a polar relay.*

Polarized Sounder.—In telegraphy, a sounder operated by an electromagnet having a permanently magnetized armature.

Polarizing Spectro-photometer. — A spectro-photometer provided with a polariscope.

Polar Pitch.—In a dynamo or motor, the armature circumference divided by the number of poles.

Polar Surfaces.—The surfaces of the poles of a magnet about which magnetic fields exist.

Polar Zone.—In electro-therapeutics, the parts of a patient's body in the immediate region of the electrodes applied to it.

Pole Armature.—An armature carrying its windings upon projecting poles arranged radially upon its surface, or extending inwards from a circular frame.

Pole Bands.—Metal bands encircling telegraph poles for the attachment of guys.

Pole Changer.—In duplex telegraphy, a transmitter which sends signals by reversing the direction of the current in the circuit; a *reverser* or *pole changing key.*

Pole Changing Switch.—A switch for reversing the direction of the current in a circuit.

Pole Clamps.—Metal clamps for attaching span wires to a pole.

Pole Clearance. — In a generator or motor, the distance between the tips of the pole pieces of adjacent field magnets.

Pole Climbers.—A device consisting of spurs properly supported and braced for attachment to a lineman's shoes to assist him in climbing a pole supporting telegraph or other electric wires.

Pole Counter.—A tally register for counting poles in a telegraph or other pole line system.

Pole Guards.—Strips of galvanized steel, and strong steel butt plates for protecting wooden poles on city streets against the gnawing of horses and the wear of colliding wagon hubs.

Pole Guy.—A rod, wire, or other appliance for stiffening a telegraph pole.

Pole Hood.—In overhead cable construction, a sheet iron cover placed over a pole top terminal.

Pole Pieces.—The steel end portions of a dynamo or motor field magnet, which are bored out so as to form the armature chamber within which the armature rotates; also called *pole shoes.*

Pole Platform.—In overhead cable construction, a small platform, protected by railings, erected upon a terminal pole below a cable box to afford safe standing room for workmen.

Pole Roof.—A metal cover sometimes furnished for the top of a wooden pole.

Poles of Condenser.—The terminals of the plates in a condenser.

Poles of Magnetic Verticity.—The magnetic poles of the earth; being points where the dipping needle would stand vertical.

Pole Strength.—In magnetism, the force exerted by a magnetic pole at a distance upon another magnet. A unit magnetic pole is a pole of such strength as to repel with a force of one dyne an equal and similar pole placed at a distance of one centimeter from it.

A magnet's pole strength can be estimated by measuring the force with which it attracts or repels another pole. the force being equal to the product of the two polar strengths. If M represents the strength of one pole and M^1 the strength of the other similarly magnetized, the force of their repulsion will be M times M^1. This force f varies inversely as the square of the distance, and may be expressed by the following formula:

$$f = \frac{M\,M^1}{d^2}$$

where d equals the distance between the poles.

Pole Support for Arc Lamp.—An arrangement for supporting an arc lamp upon the top of a pole.

Pole Tips.—The projecting and rounded edges of the pole pieces of a dynamo field magnet, usually called the *horns.*

Pole Top Terminal.—In overhead cable construction, a variety of cable head consisting of a circular cast iron box placed at the top of a pole.

Poling.—1. Planks temporarily supported against the sides of excavations to prevent caving in.

2. In copper refining, an operation in which a large pole of green birch or oak is thrust down to the bottom of the furnace containing the molten copper. Violent boiling ensues, consequent on the liberation of oxygen from dissolved oxides of copper. Frequent assays are taken, and when the specimen shows by its long silky fracture that the poling process has been sufficiently prolonged, the copper is ladled off.

3. In mining, a method used to support the roof of a tunnel which is being driven through unstable formation. Long narrow boards, laths, or *poles*, rest at a slight inclination on the top of two trestle like frames, the size of the excavation. As the work progresses, the boards are driven forward, thus keeping pace with the pick, and when projecting sufficiently far, a fresh frame is erected to support the hanging end, the process being continually repeated.

Poling Boards.—In civil engineering, the boards or planks used as lining for a trench, to retain the earth during excavation. Vertical boards are employed, being retained in place by longitudinal *waling pieces*, which in turn are stayed from one side to the other by *struts*. Poling boards are about 3 feet long, from seven to nine inches wide, by 1½ inches thick. They are driven down and fresh ones added as the trench proceeds downwards.

Polishing Bob.—A rapidly rotating disc carrying emery powder upon its periphery, for polishing metal objects preparatory to electroplating.

Polishing Mop.—A rapidly rotating disc of soft material, for polishing metal surfaces preparatory to electroplating.

Polyphase.—Having more than one phase, or period of alternation; *multiphase.*

Polyphase Alternator.—A dynamo generating polyphase alternating currents; a *polyphase generator;* a *multiphaser* or *polyphaser.*

Polyphase Armature.—An armature so wound and connected up as to produce polyphase currents.

Polyphase Armature Windings.—Methods of combining groups of coils, such as the *star* grouping and *mesh* grouping, in order to produce polyphase currents.

Polyphase Asynchronous Motor.—An asynchronous induction motor driven by polyphase currents; *a multiphase induction motor.*

Polyphase Choking Coil.—A choking coil introduced into a polyphase system.

Polyphase Circuits.—The circuits in a polyphase system.

Polyphase Currents.—Groups of alternating currents which differ in phase in a fixed proportion. If two separate sets of coils be placed on the armature of an alternator, one a little in advance of the other, two alternate currents of equal strength and frequency are obtained. These may be made to differ in phase in any desired degree by changing the positions of the two sets of coils. There are several ways of combining the circuits which receive the currents of the various phases. For instance, the windings may be divided into four separate coils, each having one end joined to a common junction, and the four outer ends joined to four line wires.

Polyphase Dynamo or Generator.—An alternator that produces currents differing symmetrically in phase; *a polyphaser.*

Polyphase Inductor Alternator.—An inductor dynamo generating polyphase alternating currents.

Polyphase Motor.—A motor driven by polyphase currents; *a multiphase motor.*

Polyphase Rotary Converter.—A rotary converter transforming polyphase into direct currents, or direct into polyphase.

Polyphase Switchboard.—A switchboard in a polyphase system.

Polyphase Synchronous Motor.—A synchronous motor driven by polyphase currents.

Polyphase System.—A system of electric conductors distributing two or more single phase alternating currents succeeding one another in a definite relation, and differing in phase in a fixed proportion; two phase and three phase systems are usually employed. Also called *polycyclic system.*

Polyphase Transformer.—A transformer employed in a polyphase system.

Polyphase Working.—The operation of a polyphase system.

Polyphote Lamp.—An arc lamp placed in series with others on the same circuit, having the regulating mechanism in parallel with the carbons and arc.

Poncelet.—A unit of activity equal to 100 kilogrammeters per second; it derives its name from *Poncelet,* a French mathematician.

Pondermotive Force.—The force exerted between two neighboring conductors of electricity, tending to move the conductors *bodily.*

Pony Insulator.—A small variety of line wire glass insulator.

Pony Relay.—A type of telegraph relay.

Poppet Valves.—The inlet and exhaust ports of a gas engine of the four cycle type are usually opened and closed by *poppet* or *mushroom valves.* These consist of metal discs, beveled around one face, so as to fit into a countersink in the port opening, and carried upon *stems* or *spindles.*

The exhaust valve is always operated mechanically from a cam-shaft; the inlet valve may be operated similarly, or may be opened by suction created by the outward movement of the piston.

Poppet valves are also in use on small steam engines using superheated steam.

Porcelain.—In electric practice, porcelain is employed for high voltage insulation because of its high insulating properties. Porcelain is composed of flint, feldspar, kaolin or china clay, and ball clay; chemically considered it is a double silicate of sodium or potassium and aluminum. It is homogeneous, giving uniform distribution to electrical strains, is practically waterproof, has great mechanical strength, can be molded into various shapes, does not deteriorate and will stand sudden and extreme temperature changes. Porcelain is well suited for spark-plug insulation, since it possesses a very high resistance both to heat and to the electric current.

The brittleness of porcelain is the worst objection to its use. Lower qualities of porcelain are, of course, much more easily broken, and thereby produce short-circuiting under ordinary conditions of temperature and electrical tension. Many plugs using porcelain insulation have the porcelain in two or more parts, so as to avoid the troubles arising from uneven temperatures. Heat is liable to break a single long porcelain.

Porcelain Insulator.—A line wire insulator made of glazed porcelain instead of glass, largely used in England and Europe because, though more costly, it does not condense moisture from the air.

Porcelain Wire Tube.—An insulating tube of porcelain for carrying an electric conductor through a wall.

Porous.—Having interstices or pores between its molecules, as unglazed earthenware.

Porous Cell.—A two fluid voltaic cell containing a cup of porous material which separates the two solutions sufficiently to retard polarization without interfering with the passage of the current; the Daniell cell is an example of porous cell.

Porous Cup.—A vessel of unglazed earthenware employed in a two fluid voltaic cell to separate the solutions sufficiently to prevent polarization. Also called *porous jar.*

Porous Insulation.—Insulation effected by a porous non-conducting material.

Porret's Phenomenon.—An enlargement of animal nerve fibre which takes place when the positive pole of an electric circuit traversing the body is applied to it.

Port.—In steam engineering, an opening or passageway through a cock, or valve; a passage whereby steam or other fluid may enter or leave a cylinder.

Portable Electrometer.—A convenient type of movable electrometer.

Portable Igniting Device.—1. A portable device for exploding a mine or blast. 2. An electric gas lighter suitable for carrying about.

Portable Tachometer.—A speed indicator conveniently adapted to being transferred from one shaft to another as occasion requires.

Portative Force of Magnet.—The power which a magnet has of carrying a weight by the force of attraction; the tractive force, or *lifting power of a magnet.*

Portelectric System.—A system of carrying parcels by electricity designed for mail transportation and similar purposes, in which a car is attracted through a succession of hollow coils of copper wire placed close together, by automatically supplying electric current to the coil immediately in advance of the car as it progresses; a *tachyphore.*

Portland Cement.—A calcined compound of chalk and clay, subsequently ground to fine powder. It possesses the valuable property of hardening under water.

Port Opening.—In a steam engine, the distance the steam edge of the valve moves past the steam edge of the port during admission; sometimes greater than the port width.

Portrait, Electric.—A portrait, or other picture, produced upon a sheet of paper by an electric discharge sent through an overlaying sheet of gold leaf containing the design.

Position Finder.—An electric apparatus employed especially in sea coast defenses, in locating the enemy's ships so that the guns may be worked with correct direction and elevation.

Positive Brushes of Dynamo.—The commutator brushes which connect with the positive terminal of a dynamo.

Positive Brushes of Motor.—The commutator brushes which connect with the positive terminal of the generator driving the motor.

Positive Bus Bar.—The bus bar which is connected with the positive terminals of a group of dynamos.

Positive Carbon.—In a continuous current arc lamp, the upper carbon rod from which the current flows across the arc to *the lower*, or *negative carbon.*

Positive Charge.—A charge of so called *vitreous* electricity, or that developed by rubbing glass with silk.

Positive Conductor.—A conductor leading from the positive terminal of a dynamo or other source of electricity.

Positive Convection of Heat.—A direction, corresponding to that of the electric currents, followed by heat in passing through an unequally heated conductor.

Positive Current.—In needle telegraphy, a current which causes a deflection of the needle to the right.

Positive Direction.—The direction in which electrostatic, magnetic, and electromagnetic lines of force are assumed to move from a positive to a negative pole.

Positive Direction Around a Circuit.—Regarded from the positive side of a circuit, a *counter clockwise direction.*

Positive Direction Through a Circuit.—The direction of the current being represented by the direction in which a corkscrew enters a cork, the positive direction of the lines of force through the circuit will be that in which the handle of the screw turns.

Positive Electric Fluid.—According to an early theory of electricity, known as the double fluid theory, that "imponderable" fluid which is the cause of positive electricity.

Positive Electricity.—The kind of electricity developed by rubbing glass with silk; *vitreous* electricity. This term expresses the condition of the point of an electrified body having the higher energy from which it flows to a lower level, just as a current of steam is impelled through pipes by the generating pressure at the steam boiler. The sign which denotes this phase of electric excitement is +; all electricity is either positive, or, —, negative.

Positive Electrification.—A positive charge.

Positive Electrode.—1. In a primary cell, the zinc plate, or *anode*, is the *positive electrode*, while the *pole* of this electrode is the *negative* pole, because it is negative in relation to the external circuit.

2. In a storage cell, the peroxide plate which is the cathode during discharge, is called the *positive* electrode, and its pole the positive pole.

3. In electroplating, the anode or the metal plate through which the current enters the solution.

Positive Element of Voltaic Cell.—The positive electrode, the plate from which the current passes to the negative plate; the *zinc plate* or *anode*.

Positive Feeders.—The conductors leading from positive mains to the positive terminals of a dynamo.

Positive Omnibus Bar.—A positive *bus bar*.

Positive Phase of Electrotonus.—An effect of increasing the electromotive force in a nerve, produced when a current is passed through the nerve in the same direction as the nerve current.

Positive Plate of Primary Cell.—The positive element in a primary or *voltaic cell*.

Positive Plate of Storage Cell.—The plate which is converted into peroxide of lead, to which the current flows from the negative plate in the process of discharging; it is usually of a brownish color.

Positive Pole.—1. The north seeking or plus (+) pole of a magnet.

2. The terminal of an electric generator out of which the current is assumed to pass into the external circuit.

3. The pole of an electro-receptive device connected with the positive pole of a source.

Positive Potential.—In general, the higher potential which causes lines of force to flow towards a lower, or negative potential.

Positive Rotation.—Left handed or counter clockwise rotation. A rotary motion in a direction opposite to the movement of the hands of a clock as seen when one reads the time. A right to left rotation.

Positive Side of Circuit.—The side of a circuit opposite to the negative side, such that, when a current is considered as flowing in a circle about an observer who has his head in the positive region, the current would appear to flow from his right towards his left, with *counter clockwise rotation*.

Positive Simple Harmonic Motion.—Simple harmonic motion partaking of a right to left, or *counter clockwise direction*.

Positive Spark.—A spark produced by positive electrification.

Positive Terminal.—1. In a primary cell, the terminal of the negative plate.

2. The positive pole of a generator or electro-receptive device.

Positive Wire.—1. A conductor leading to the positive pole of a generator.

2. A wire having a positive potential.

Positively Excited.—Charged with positive electricity, as when glass is rubbed with silk.

Post Office.—A designation for the types of electrical apparatus employed by the British Post Office in its *telegraph system*.

Post Office Bridge.—A resistance box, being a box form of Wheatstone bridge, as employed by the British telegraph department.

Potash Brush.—A brush for cleaning metal surfaces by applying a caustic, preparatory to *electroplating*.

Potassium.—A bright, silvery white metal, of a specific gravity of .875, melting at 155° Fahr. It oxidizes very readily, so has to be kept submerged in naphtha, which contains no oxygen. Being lighter than water, it floats when thrown into that liquid, at the same time decomposing it, forming potassium hydrate, and liberating part of the hydrogen of the water. The chemical action is so violent, that this escaping hydrogen ignites, burning with a lavender colored flame.

Potassium Bichromate.—A red crystalline solid, soluble in water, poisonous. When mixed with sulphuric acid it is used as a depolarizer in primary cells of the Poggendorff type requiring a liquid depolarizer, such as the Grenet and Fuller cells.

Potassium Carbonate.—Potash. It is found in commerce in grayish-white, bluish and yellowish pieces. When pure it is in the form of white powder or in small pellets. Being very deliquescent, it has to be kept in closed vessels. In electroplating it serves as an addition to some baths, and in its impure state is used for freeing objects from grease.

Potassium Chlorate.—A white solid crystalline substance, soluble in water. It is used as an oxidizing agent, in testing for poisons, in the preparation of aniline black dye, in fireworks, for matches, etc. It may be prepared by the electrolysis of potassium chloride solutions, using a copper or iron cathode and a platinum anode.

Potassium Cyanide.—A white crystalline solid, very soluble in water, very poisonous. It is a powerful reducing agent, so that when heated with metallic oxides it reduces many of them, and hence is used in blowpipe analysis. Its aqueous solution dissolves platinum and its dilute aqueous solution with access of air dissolves gold. It is used in preparing the solutions used in electroplating silver and gold, as it dissolves many cyanides which are insoluble in water.

Potassium Hydrate.—Caustic potash. Found in commerce in various degrees of purity either in sticks or cakes. Pure caustic potash is used in electroplating as an addition to zinc and gold baths, and the impure commercial article is used to free objects from grease.

Potassium Nitrate.—Also called *saltpeter* and *niter*. A white solid crystalline substance, very soluble in water, occurring naturally in rich soils and in spring and river waters. It is made on a large scale by the double decomposition between potassium chloride and sodium nitrate. It is used in the preparation of explosives, as a food preservative, in electroplating as a desilvering pickle, and for producing a matt luster upon gold and gilding.

Potassium Sulphide.—Forms a hard greenish yellow to pale brown mass with conchoidal fracture. It readily absorbs moisture which causes it to deliquesce and smell of sulphuretted hydrogen. It is employed in electroplating for coloring copper and silver black.

Potential Difference.—The difference of electric potential or pressure in a circuit which creates the *electromotive force*. It is this force that causes a current to flow from a point in a circuit which has higher potential to another that has lower potential, and is equal to the amount of work which must be done on a positive unit of electricity to bring it from one point to the other. It is measured in a unit called the *volt*.

Potential Dynamometer.—An electrodynamometer suitable for determining differences of potential.

Potential, Electric.—The power possessed by a charge of electricity for doing work; such that when a difference of potential is occasioned in the same conducting body, an electric current flows from the higher to the lower potential.

Potential Energy.—Energy, or power for doing work, in reserve; latent, or static energy, as distinguished from *kinetic energy*. Potential or static energy is a capacity for doing work due to advantage of position or other cause.

Potential Gradient.—A line tracing the rate at which electric potential falls in a circuit.

Potential Indicator.—An instrument for indicating a difference of electrical potential; as, a *voltmeter*.

Potential of Conductors.—The electrical condition of a conductor which determines the direction of the flow of a current of electricity in that conductor.

Potential Regulator.—In an alternating current circuit, a form of stationary induction apparatus having one coil in shunt and the other in series with the circuit, so arranged that the ratio of transformation between them is variable at will. Potential regulators are of three types: (1) compensator, (2) induction, and (3) magneto potential regulators.

Potentiometer.—An arrangement of carefully standardized resistances for measuring voltages in comparison with a standard cell. It is used for accurate measurement of currents, voltages and resistances.

Potentiometer Voltmeter.—A voltmeter made upon the principle of a potentiometer.

Potentiometer Wire.—A graduated wire like that of a meter bridge, employed in a potentiometer, so that at any point along the wire any proportional part of the whole electromotive force may be taken for comparison.

Pot Head Terminal.—In underground construction a method of terminating the lead armor. The pot head is soldered to the lead covering and is filled with pitch. The pot head serves to localize stray currents that might prove disasterous to the cable and by thoroughly grounding the lead covering these stray currents are effectively dissipated.

Pot Valve.—A safety valve shaped like an inverted pot. It is a *lift valve* and the coni-

cal pivot of the lever drops loosely into a recess in the crown of the pot. The advantage claimed is that such valves being in a condition of unstable equilibrium, are less liable to *stick* than the ordinary form. The lift of the valve is controlled and maintained by a guide, cast on the top of the seating.

Poundal.—A British unit of force, equal to the force which acting for a second upon a mass weighing one pound causes it to acquire a velocity of one foot in a second. It is equal to the weight of a pound mass divided by the acceleration of gravity; that is, 13,825 dynes or about half an ounce.

Pound Calorie.—The quantity of heat required to raise the temperature of one pound of water one degree C. One pound calorie = 1.8 B. T. U. = .4536 calorie.

Pound of Steam.—A pound of water which has been converted into steam. After such a change (i. e., water into steam, or the reverse), the weight approximately remains the same.

Pounds per Mile Ohm.—The weight in pounds of a conductor a mile long and of such uniform cross section as to offer a resistance of one ohm; a standard employed in conductivity tests of telegraph and telephone wires.

Powdered Coal.—Coal that has been broken or ground into minute fragments. Used as fuel in the rotary kilns in which Portland cement is clinkered, as firing for various brickmaking processes, and as part of the composition of certain porous tiles and bricks, the coal burning out as the articles are fired, leaving them in a spongy or porous state.

Powder Transmitter.—A form of telephone transmitter employing granulated carbon as the varying resistance medium; a *carbon dust transmitter.*

Power.—The rate at which work is done; that is, work divided by the time in which it is done. The most common unit of power is the horse power, or 33,000 foot pounds per minute.

Power Absorbed in Circuits.—In any part of a circuit, the power expended is proportional to the resistance of that part. Hence, the resistance of circuits must be kept low. To accomplish this copper of high conductivity must be used, but the size of the wire, on account of the high price of the metal, must be small. The transmission of current to any considerable distance is not economical, if the reduction of waste is obtained merely by increasing the conductivity of the leads. To transmit electrical energy economically to distant points, the current must be comparatively small, traversing a thin wire, and the electric pressure high.

Power Cable.—An electric cable used in the distribution of electric power.

Power Calculations.—To compute the horse power required to raise a given quantity of water to a certain height, multiply the gallons per minute by 8.35, and this product by the height in feet; the result will be the work done in foot pounds. To reduce this to horse power per minute, divide by 33,000. Usually, an allowance of 50 per cent. is made for friction and other loss.

To estimate the electrical energy required to deliver an electric load, multiply the amperes by the voltage, the product will be the total number of watts. An electrical horse power is 746 watts, therefore, divide the total number of watts by 746 and the result will be the electrical horse power. To ascertain the brake horse power of an engine when direct connected to generator, multiply the amperes by the voltage and divide by 660; the result will be the approximate brake horse power of the engine. If the engine is of the belted type, divide the total number of watts by 550 instead of 660. In computing the horse power it is customary to allow ten 16 candle power lights to the horse power. A 16 candle power light is equal to 55 watts.

Power Circuits.—Electric circuits concerned with the distribution of electric power.

Power Curve.—In a diagram of alternating current curves, a curve produced by multiplying the amplitudes of the electromotive force and the current; the *volt ampere curve* or *curve of watts.*

Power Cylinder.—In the controller of an electric street car the main cylinder provided with contacts for applying the power, as distinguished from the reversing cylinder.

Power, Electric.—A rate of doing work produced by electricity in motion; the activity of electric energy measured in watts or kilowatts; its unit is the *watt.*

Power Factor.—In alternating current circuits, the ratio of the electric power in watts to the apparent power in *volt amperes.*

Power Factor of Transformer.—The ratio of the true watts to the apparent watts acted upon by a transformer.

Power Generator.—Constantly driven generators employed in telephone exchang-

es for ringing purposes, in order to save the operators the necessity of turning a crank to ring a bell whenever a subscriber is wanted.

Power House.—A building specially constructed to accommodate the electric plant concerned in the generation and distribution of electric power. Radiating from the power house are distributing leads consisting of *feeders* leading into a network of wires which run from house to house. Supply systems are classified according to the pressure; as (1) *low voltage*, 100 to 300 volts, (2) *high voltage*, 300 to 3000 volts, and (3) *extra high voltage*, over 3000 volts. Continuous currents are generally used on the low voltage systems and alternating currents with high pressure systems, transformers being used to lower the pressure at the consumers' houses.

Power in Alternating Circuit.—The product of the corresponding instantaneous current and pressure multiplied by the cosine of the angle of lag.

Power Meter.—A term sometimes applied to a *wattmeter*, an instrument for measuring directly in watts the electric power expended in a circuit.

Power Lift.—A platform or cage working in suitable guides, and operated by electric or other power, used to raise or lower weighty articles; an elevator used for transporting goods rather than passengers.

Power Station.—The central point where power is generated, and whence it is distributed to desired localities.

Power Stroke.—In the cycle of operation of an internal combustion engine, the stroke during which the combustion of the fuel mixture occurs, as distinguished from the *non-power* strokes of the cycle. A power stroke occurs once in every revolution of a two cycle engine, and once in every two revolutions for a four cycle engine.

Power Switchboard.—A remote control switchboard operated by mechanical means instead of by hand, usually electricity is employed for the purpose, though a few installations have used compressed air.

Power Transmission.—1. As applied to electric engineering, power transmission is the transmission of electric current from a more or less distant point or station to a center from which the power is distributed, or to power motors at different points in an installation. Long distance transmission is accomplished by high tension alternating currents distributed by the three phase three wire system and the two phase four wire system, the former being used for greatest distances to economise copper.

2. Distribution of power from central plants to a number of more or less scattered points, thus securing the economy consequent upon large and compact units, which may be situated advantageously near sources of water power, coal mines, etc. The chief methods of transmission are *wire rope* for short distances, *hydraulic*, *pneumatic* or *electric* power for longer, each plan having special advantages for certain purposes.

Power Unit.—A term sometimes applied to the *watt*. It is equal to one joule of electric energy expended per second, and is the rate at which work is done when one ampere flows through a resistance of one ohm. The practical unit of electric power for convenience is the kilowatt which is equal to one thousand watts.

Power Wire.—In the monocyclic alternating current system, the third wire employed as an auxiliary and for starting the motor.

P. P. D.—Abbreviation for primary potential difference.

Practical Daniell Cell.—An inexpensive and easily made form of Daniell cell consists of a U-shaped tube with a little cotton pushed down to the botton of the bend to form the porous partition. A saturated solution of sulphate of copper is put into one leg of the tube and a solution of sulphate of zinc in the other. The positive plate consists of a rod of chemically pure zinc and the negative plate is a rod of pure copper. These rods are inserted through corks which are placed in the tube ends. Such a cell can be put together in a few minutes and gives a reliable standard of electromotive force, good enough for ordinary work, the current, however, is small compared to the usual form of Daniell cell.

Practical Solenoid. — A solenoid employed in actual practice, as distinguished from *an ideal solenoid*.

Practical Unit of Current.—The *ampere*. It is that value of current which will cause the electrolytic deposition of silver at the rate of 0.001118 grams per second. It is the rate of flow of an electric current carrying one coulomb per second.

Practical Unit of Electromotive Force.—The *volt*. It is the E. M. F. that will cause a current of one ampere to flow in a conductor through a resistance of one ohm.

Practical Unit of Inductance.—The *henry*. An inductance of one henry exists

in a circuit when a current changing at a rate of one ampere per second induces an electromotive force of one volt in the circuit.

Practical Unit of Magnetomotive Force.—A value equivalent to one-tenth of the absolute unit of magnetomotive force.

Practical Unit of Resistance.—The *ohm.* It is the resistance of a column of mercury 106.3 cm. long, of uniform cross-section, and weighing 14.4521 grams at 0° C. A conductor has a resistance of one ohm when it requires one volt pressure to send through it a current of one ampere.

Practical Units.—Units of electrical measurement based upon the absolute Centimeter Gram Second units, but more convenient for practical use.

Preamble.—The introductory matter in a telegraphic message consisting of service details, as distinguished from the message proper.

Precipitate.—A substance which, having been dissolved, is again separated from its solvent, and thrown to the bottom of the vessel, by pouring in another liquor.

Precipitation.—The act of throwing down; specifically, the deposition, as sediment, of any substance dissolved in an acid solution on the addition of an alkaline reagent.

Preece, Sir William Henry.—Born 1834. An English electrical engineer, distinguished for his contributions to electrical science, especially in *telegraphy.*

Prefix.—A code signal preceding a telegraphic message in order to signify the special character of the message.

Pre-ignition.—In gas engine ignition, a term used to denote that the fuel mixture is ignited before the time of the spark, and has no connection with the stroke or crank position at the time of the ignition.

Prepayment Meter.—An instrument for regulating, measuring and indicating electrical supply, especially in residences of uncertain tenancy, such as tenements. A designated coin deposited in the slot will permit a certain amount of current supply to pass. The prepayment meter requires elaborate mechanism to respond when the proper coin is deposited, and to be proof against tampering.

Preservation of Timber.—Best effected by using well seasoned timber and keeping it well ventilated. Large posts should be bored longitudinally, with a transverse hole at top and bottom, while a space should be left around all built into masonry. All woodwork in contact with outside masonry, should have the back painted and no chance allowed for lodgment of moisture. Posts to be put in the ground should be dipped in coal tar, or else have the buried parts charred. Timber kept constantly submerged will keep indefinitely, but all exposed to intermittent wetting should be creosoted. Of artificial processes, *creosoting,* as described for railway sleepers, is admitted to be equal to any, and better than others as regards baffling the *teredo.*

Press Block.—In armature winding, a pair of blocks shaped to fit into each other so as to give a final form to a form wound coil when pressed between them.

Press Button.—A push button; a spring contact to close the circuit in operating an electric bell.

Pressed Steel.—Steel plate bent or pressed by means of dies into channel or other sectional forms, giving great strength with a minimum weight of metal.

Pressel.—A push button contact set in a pear shaped handle at the end of a flexible cord, for conveniently ringing a bell or lighting an electric lamp.

Press Message.—A telegraphic message designed for a newspaper; a despatch for the daily press.

Presspahn.—A name sometimes given to *fullerboard,* a useful material for insulating armature slots. It is mechanically tough and has high disruptive strength.

Pressure.—The action of a force against some obstacle or opposing force.

Pressure, Electric.—The potential difference, or difference of electric potential in a circuit creates an *electric pressure* or *electromotive force* through the circuit. If one point in a circuit is of a higher potential than another, a current of electricity will flow from the higher to the lower potential, just as pressure will cause water to run from a higher to a lower level, or a pressure of steam will force a current of steam through an opening. Electric pressure is generally known as *electromotive force* (E. M. F.) or more commonly as *voltage.*

Pressure Gauge.—A dial instrument for registering the pressure of a fluid or liquid confined within a pipe or chamber. The

usual pattern operates by the tendency of a bent oval tube to straighten itself under pressure. Mercurial columns are used for accurate measurements or for testing mechanical gauges. Inverted syphons containing oil or water are used to measure air pressures, such instruments being often known as *piezometers*.

Pressure Indicator.—An accurate form of voltmeter whose index stands at zero when the pressure in the circuit is normal, used especially in electric light plants to show any deviation from the exact pressure required for an incandescent system.

Pressure Panel.—In a central power station, a switchboard panel provided with a device for indicating the mean electric pressure of that station.

Pressure Wires.—Light copper wires tapping an underground main at points where the feeders join the mains, and running to the central station to indicate the pressure supplied at those points.

Prevention of Smoke.—This necessary sanitary and economic precaution is effected usually by one of three broad methods: (1) the use of smokeless fuel; such as gas, anthracite coal, etc.; (2) careful and systematic firing, generally effected by means of mechanical stokers; (3) burning the products of combustion before letting them pass into the atmosphere, either in subsidiary furnaces, or by special arrangements of the fireplaces, gas passages, and the like.

Pricking.—A method of locating a wire in a cable by pricking through the insulation with a brad awl connected in circuit with a grounded battery.

Primary Admittance.—Admittance in the primary coil of a transformer, or in the primary of an induction coil.

Primary Ampere Turns.—The ampere turns in the primary coil of a transformer or induction coil.

Primary Battery.—1. A group of primary cells connected together in order to act as a single electric source.

2. In gas engine ignition, a primary battery generally consists of between four and six open-circuit dry cells in series, giving a pressure of between 1 and 1½ volts per cell. Two such batteries are generally included in the outfit, either of them being switched into circuit, as required, or both being connected in multiple, to give a greater current at the same voltage. In many cases the chemical battery is used only for sparking at the start of the engine, and until the magneto or dynamo has attained sufficient speed for continuous effect, being then automatically switched out of circuit. It is necessary to use the open circuit type of cell, since the current must be periodically interrupted.

Primary Cell.—A device for transforming chemical action into electric current. Volta discovered that an electromotive force may be created between two dissimilar substances through chemical action set up by a solution in which they are immersed. This discovery led to the construction of the primary cell, long known as the *voltaic* cell. The cell consists essentially of two plates of different substances standing apart in a jar containing a solution which attacks one and not the other. By joining the outside terminals of the plates by a conducting wire, a current will flow from one to the other so long as the chemical action or *electrolysis* continues through the solution. The solution is known as the *electrolyte*, and the two plates, the *electrodes*. This type of cell is called *primary* to distinguish it from the *secondary* or storage cell.

Primary Clock.—In a system of electric time keeping, the *master clock* which controls the movements of a series of *secondary* clocks at different points in its circuit.

Primary Coil.—1. In a transformer, a coil usually consisting of many turns of insulated copper wire which receives the alternating current at high pressure for transformation into a large current at low pressure.

2. In an induction coil, the coil in which the original current acts inductively upon the secondary; the *primary*, as distinguished from the *secondary*.

Primary Current.—1. The current in the primary of a transformer.

2. A current in the circuit of a primary or voltaic battery.

Primary Cut Out.—A safety cut out included in the circuit of the primary coil of a transformer.

Primary Electric Heater.—In an electric heating system, the principal heater.

Primary Electromotive Force.—The electromotive force in the circuit of the primary of a transformer.

Primary Fuse Box.—A fuse box included in the circuit of the primary coil of a transformer.

Primary Impedance.—The impedance existing in the circuit of a primary coil.

Primary of Induction Motor.—The field coils of an induction motor; usually the fixed part, or *stator*.

Primary Plate.—The disc or plate of a condenser that receives the positive charge which acts inductively across the dielectric upon the secondary plate.

Primary Powers.—These are: 1, water power; 2, wind power; 3, tide power; 4, the power of combustion; 5, the power of vital action.

Primary Source of Light.—A luminous source which radiates luminous energy as the result of high temperature originating within itself.

Primary Spark.—An electrical ignition device for explosion engines, which receives electricity from a primary battery instead of from accumulators or small dynamos.

Prime Conductor.—In the cylinder electrical machine, an elongated metal cylinder, with rounded ends, supported upon a glass stand, having one end provided with a metallic *comb*, and the other with a rod terminating in a brass knob. The prime conductor collects the charge as follows: The charge on the *rotor* acts inductively on the long insulated conductor, repelling a plus charge to the far end and leaving the nearer end negatively charged. A negatively electrified wind is emitted by the row of points towards the positive charge upon the rotor, which is thereby neutralised.

Prime Flux Density.—The number of magnetic lines that run through unit area of cross section of a substance magnetized by a prime magnetic flux.

Prime Magnetic Flux.—The total lines of magnetic force in a magnetic circuit due to a direct magnetizing force, as distinguished from magnetic induction.

Prime Magnetomotive Force.—The magnetizing force producing prime magnetic flux in a magnetic circuit.

Prime Mover.—An apparatus or mechanism whereby motion and force are received directly *from some natural source of energy*, and transmitted into some form of motion by means of which the power may be conveniently applied. The sources of energy are: muscular energy, as the power exerted by men and animals, the man or animal constituting the prime mover; gravity, exemplified in the driving of a clock, by the falling of its weights, or in the operation of a water wheel by the weight of falling water; motion of fluids, as in a windmill; heat, as in a steam engine and boiler, whereby the heat of the fuel is converted into the motion of the crank shaft; chemical energy, as in the firing of a gun, or the generation of electricity in a primary battery.

Principal Circuit.—A main circuit, as distinguished from a derived or branch circuit.

Principal Current.—The current flowing through a main or principal circuit.

Printing Telegraph.—An automatic telegraphic machine which prints the message, as it is received, upon an uncoiling tape or strip of paper. The Morse alphabet or common Roman type is employed.

Prism.—1. A transparent body with, usually, three rectangular plane faces or sides, and two equal and parallel triangular ends or bases; used in experiments on refraction, dispersion, etc. Prisms of different forms are often named from the figure of their bases; as a triangular prism, a quadrangular prism, a rhombic prism.

2. In optics, etc., a piece of transparent refracting material in the form of a prism, usually with three equal rectangular faces and of triangular cross section.

Prismatic Compass.—A form of compass used in surveying, provided with a metal frame and a stretched horse hair for a sight vane, opposite which is a right angled prism with an eye hole and slit.

Private Line.—A telephone line connecting a central station with a single subscriber, or a subscriber with only one other, as distinguished from a *party line*.

Probe, Electric.—A surgical instrument for locating a bullet or other metallic matter in the human body by closing an electric circuit when the probe makes contact with the foreign substance.

Producer Gas.—A mixture of combustible gases, which is prepared by the combustion of fuel apart from the furnace to be heated. The gases after passing from the gas producer furnace, are heated in regenerators; they mingle and burn on their furnace hearth with atmospheric air similarly heated. Producer gas is prepared from inferior fuel, but chiefly from bituminous coal.

Products of Combustion.—In steam engineering, the combustible parts of coal are hydrogen, carbon and sulphur; and the unburnable parts are nitrogen, water; and

Prognosis, Electric.—In electro-therapeutics, a forecasting of the probable outcome of a disease, after a diagnosis by the application of electricity to the body.

the incombustible solid matters such as ashes and cinder. In the operation of firing under a boiler the first three elements are totally consumed and form heat; the nitrogen and water in the form of steam, escape to the flue, and the ashes and cinders fall under the grates.

Progression of Magnetic Field.—The progress of the magnetic poles along the face of a multipolar stator of a polyphase motor.

Projecting Power of Magnet.—The power which a magnet has of projecting lines of force beyond its poles.

Projection Armature.—A slotted armature having recesses of sufficient depth to leave projections upon its surface after all the windings are laid on.

Projector, Electric.—A searchlight, or lantern containing a focusing arc lamp.

Projection Lamp.—A focusing arc lamp provided with a mechanism such that the carbons are fed towards each other as they wear away so as always to maintain the arc at the exact focus of the reflector which projects the light. Projector lamps are used for searchlights in theaters, and for photo-engraving purposes.

Prony Brake.—A form of dynamometer for computing the power delivered by a revolving shaft, consisting essentially of a clamping device applied to a pulley fixed to the shaft, and a lever and weight for obtaining the required data for the computation.

The delivered or brake horse power is calculated from the following formula:

$$\text{H. P.} = \frac{2\pi \text{R N W}}{33{,}000}$$

in which

W=unbalanced weight in pounds, acting on lever arm at distance R;

R=length of lever arm in feet from centre of shaft;

N=number of revolutions per minute.

H. P.=horse power

Soft woods are preferred to hard woods for brake blocks. The rubbing surface should be well lubricated with a heavy grease.

Proof Plane.—A small metal disc with an insulated handle, used to collect electricity by contact with a charged body, for purposes of testing or experimenting.

Propeller.—That which transmits the power of the engine to the water; generally speaking, the screw propeller, which is a spirally vaned wheel whose rotation displaces the water, consequently driving the vessel along.

In automobiles, a fan resembling a screw propeller in appearance, which induces a draught through the radiator which cools the circulating water; in air cooled engines the fan drives air over the cylinders to maintain them at a moderate temperature, instead of using water circulation for that purpose.

Propelling Drag.—A retarding force in a generator which acts in a direction that opposes the rotation, and is, in fact, a counterforce or reaction against the driving force. In a motor the drag is the driving force, and produces the rotation.

Proportional Coils.—In electrical measurement, resistance coils of known resistances, usually in tens, hundreds or thousands of ohms, connected in a box in such a way as to form a bridge, as in the "dial" and "post-office" patterns of Wheatstone's bridge.

Proportionate Arms.—In electrical measurement, the arms of known resistance of a Wheatstone bridge; the *ratio arms*.

Propulsion, Electric.—The use of electricity as motive power.

Prostration, Electric.—Physical prostration with symptoms resembling those of sunstroke, sometimes occasioned by too great exposure to the rays of an intense arc light. The skin is sometimes affected to such a degree as to come off after a few days. The throat, forehead and face suffer pains, and the eyes are irritated. These effects only follow exposure to very intense sources of light, or for very long times.

Protecting Battery.—A battery connected to a faulty submarine cable for the purpose of sending a negative current through the fault to prevent corrosion

Protection, Electric.—The use of lightning arresters for the protection of electric systems and apparatus from injury by lightning.

Protection of Metals, Electric.—A method of preventing the corrosion of a metal, as the copper sheathing of a ship's bottom, by placing another metal, as zinc, in connection with it, so that the zinc, acting as the positive element of a voltaic battery, suffers the corrosion, and saves the copper.

Protective Relay.—A device for opening or closing a circuit and protecting it from dangerous conditions such as overloads, short circuits, reversal of current, etc. They act in conjunction with automatic circuit breakers operating when the predetermined condition has occurred, energizing the trip coils of the breakers and opening the circuit.

Protective Sheath.—A sheet of copper, connected to ground, introduced between the primary and secondary coils of a transformer to prevent any possible electrical connection between the two windings.

Protective Throw.—The protection given to metals by a magnetic field, producing the power of concentrating lines of magnetic force while exposed to chemical action.

Protector, Electric.—A device for guarding the human body from destructive or injurious electric shocks. In one system, Delany's, the wrists and ankles are encircled by conducting bands, which, by wires running along the arms, back and legs, are connected. A discharge, it is assumed, received by the hands will thus be short circuited around the body and its vital organs.

Protoplasm.—The lowest form of animal and vegetable life. It is a viscid semi-transparent substance possessed of vital properties forming the original living cell; also called *bioplasm*.

Prussic Acid.—Hydrocyanic acid. An extremely poisonous acid. It exists in nature in a state of combination in certain vegetables and fruits, especially in the kernels of stone fruits, such as plum, apricot, almond, cherry, etc. In electroplating, it is employed in the preparation of gold immersion baths, and for the decomposition of the potassa in old silver baths.

Public Supply Instruments.—Meters for recording the amount of electricity furnished to consumers.

Puddle.—Clay, mixed with water to form a plastic mass, used to line reservoirs, water channels, cofferdams, etc., where an impervious material is necessary.

Puddling.—The process by which wrought iron is manufactured from cast, the material being known as *forge pig*. The puddling furnace is of the reverberatory type, its hearth having a cast iron bottom, covered or *fettled* with *bull dog* or *mill scale*. The pig is fed to the furnace with a charge of slag, and, as it melts, the slag forms a surface over it preventing oxidation; while molten, the carbon, silicon, etc., are absorbed by the fettling, this raises the melting point, and the iron begins to solidify into a pasty mass. At this point it is *rabbled*, or worked with iron rods, and the mass worked about to bring it into better contact with the ferric oxide of the bed, which absorbs more carbon. The iron is then worked into *blooms* or *balls*, a spongy pasty mass, and removed from the furnace to the *shingling hammer*, where the slag is beaten out of it. After this operation, with the same original heat, it is passed through the rolls, forming *puddled bar*, which is also known, from its contained impurities, as *muck bar*.

Pull.—An electric contact maker which closes a circuit by a pull, sometimes used in place of a push button; a pull contact.

Pulley.—One of the mechanical powers; consisting, in its simplest form, of a grooved wheel, called a sheave, turning within a movable frame or block by means of a cord or rope attached at one end to a fixed point. The force acting on the free end of the rope is thus doubled, but can move the load only through half the space traversed by itself.

Pulling Jack.—A hydraulic or screw jack having the reverse motion of a lifting jack, as its power is empolyed in shortening itself instead of an extension of its length; it is thus applicable for the purpose of pulling things together.

Pull Over.—A trolley hanger designed to suspend the trolley wire in proper position and at the right tension in making a curve; *a pull off*.

Pulsating Current.—A current equivalent to the superposition of an alternating current upon a continuous current; a *pulsatory current*.

Pulsating Wave.—In periodically varying motion, a wave in which one half has a greater value than the other; as distinguished from an *alternating* wave in which the positive and negative values are equal.

Pulsation, Electric.—A throbbing of electrical flow, due to a pulsatory electromotive force.

Pulsation of Reactance.—A periodic variation of the reactance in an alternating current circuit, producing higher harmonics of the current wave.

Pulsation of Resistance.—A periodic variation of the resistance in an alternating current circuit, producing higher harmonics of the current wave.

Pulsatory Current.—A continuous current, constant in direction, but periodically varying in intensity so as to progress in a series of throbbings or pulsations, instead of with uniform strength.

Pulsatory Electromotive Force.—An E. M. F. subject to periodic changes in value, so as to produce a pulsatory current.

Pulsatory Field.—An electromagnetic field producing pulsatory currents.

Pulse, Electric.—A throbbing of electric current.

Pump.—A hydraulic machine, variously constructed, for raising or transferring fluids, consisting essentially of a moving piece or piston working in a hollow cylinder or other cavity, with valves properly placed for admitting or retaining the fluid as it is drawn or driven through them by the action of the pistons; as, an *air pump*, a *rotary pump*, or *power pump*. The latter is often driven by electricity.

Pumping Engine.—A reciprocating stationary engine of large size, designed for pumping water. Such engines have the steadiest load of any land engines, and are usually fitted with every refinement to produce efficiency.

Pumping of Alternator.—A pulsating action in an alternator intended to run in step with another in parallel, when the synchronism is not exact.

Pumping of Electric Lights.—1. A rapidly recurring change in the intensity of the light of incandescent lamps due to faulty action of the dynamos.

2. In arc lamps, an active rise and fall of the carbons, producing a hissing arc and practically no light when the potential difference between the carbons falls below 40 volts.

Pump Log Conduit.—In underground cable laying, a cheap and simple form of conduit composed of creosoted wood tubes.

Pumps, Electric.—Pumps suitable for many services are built to be driven by electric motors, and special designs have been made to cover the requirements of hydraulic elevator service, mine service, water works supply, irrigation purposes, fire protection, or in short any service where electric motive power can be used to advantage. The great variety in style and size of these pumps now in successful use assures the extension and enlargement of the application of electric motors to all kinds of pumping machinery.

Punched Clip Switch.—A clip switch having the clips punched from sheet metal.

Punching Bear.—A portable press, operated either by screw gear or a small hydraulic ram, for punching holes in erection or other field work.

Punning.—Packing earth tightly about the foot of a newly erected telegraph pole.

Pupillary Photometer.—A form of photometer which compares the brilliancy of lights by noting the degree of contraction produced by them upon the pupil of the eye.

Pupin, Michael Idvorsky.—Born 1858, in Hungary. Electrician and inventor, noted for his researches in electrical resonance, electromagnetic waves, and the magnetization of iron; inventor (1899) of a system of telephony in which self-induction coils are introduced at intervals along the line, so that the vibrations are conveyed to great distances without loss of strength, thereby greatly extending the limits of long distance telephone work.

Pure Spectrum.—A spectrum of light with sharp and distinct lines, free from the blurring commonly seen when the colors overlap.

Push Box.—A box containing the contacts and springs for the operation of a push button.

Push Button.—A contact device for ringing an electric bell and for similar purposes, which is operated by pressing a button to close a circuit. The button is applied to a spring so that when pushed in and released it springs back; thus the circuit is closed only as long as the button is pressed.

Push Button Lamp Socket.—An incandescent lamp socket containing a push button contact for lighting and extinguishing the lamp.

Push Button Socket.—A wall socket fitted with a push button.

Push Button Switch.—A small switch operated by a push button for controlling one or more incandescent lamps.

Putlog.—A squared scantling used to support the boards in a bricklayers' scaffolding. The putlog rests with one end in a hole in the wall and the other rests upon the *ledgers* or *runners*. In stonemasons' heavy scaffolds, there are no putlog holes, an inner scaffold being put up to support the wall end of the putlogs.

Putlog Hole.—An aperture formed in a wall by the omission of a header brick. It serves to receive the putlog or transverse support of the scaffold boards.

Putty.—1. A cement used by painters and glaziers for stopping nail holes or defects in woodwork or iron before painting; for securing glass in window frames, etc. It is made of dry whiting (pure chalk ground and washed) mixed with raw linseed oil. Putty used in hot countries should have a little cottonseed oil added to retard the drying, and for glazing requires the addition of ten per cent. white lead to increase its durability.

2. A cement used by engineers, made of red lead mixed with white lead and linseed oil; especially useful for joints between rough surfaces; as, on boiler mountings.

3. A thin mortar, having considerable water added to it, employed by plasterers.

4. A paste composed of lime and water, used by plasterers and builders.

Pyknometer.—An instrument for determining the specific gravity of solids, consisting essentially of a glass bottle with a long tubular neck combined with a thermometer; *a specific gravity bottle.*

Pyrites.—A mineral, usually whitish or yellow with a bright luster; any one of the metallic sulphides; as, of iron or copper.

Pyro-electric Crystal.—A crystalline body which gives electrical effects when unequally heated or cooled.

Pyro-electricity.—Electrical charges exhibited by certain crystalline substances, especially *tourmaline,* in the process of heating or cooling. A heated crystal of tourmaline suspended by a silk fibre may be attracted and repelled by electrified bodies, or by a second heated tourmaline crystal. If a crystal be broken up, each fragment is found to possess also an analogous and an antilogous pole. Many other crystals besides tourmaline are pyro-electric. When a natural hexagonal prism of quartz is heated, its six edges are found to be positively and negatively electrified in alternate order.

Pyrogravure.—Burning a design upon wood or other substance with a tool heated by electricity.

Pyromagnetic Dynamo.—A machine which generates electricity from heat by the operation of pyromagnetism; *thermo-magnetic dynamo.*

Pyromagnetic Motor.—A motor operated by pyromagnetism which causes an armature to be attracted and released by the influence of heat upon its magnetic properties.

Pyromagnetism.—The changes produced in the magnetic properties of a substance, especially nickel and iron, by the action of heat; *thermo-magnetism.*

Pyrometer.—An instrument for measuring degrees of heat above those indicated by the mercurial thermometer, constructed usually on the principle of registering, or measuring, by means of multiplying levers and a scale, the change in length of some expansible substance, as a metallic rod when exposed to the heat to be measured.

Pyrometer, Electric.—A sensitive pyrometer for exact measurements utilizing the changes in electrical resistance of platinum when heated. As devised by Chatelier it consists of two pieces of wire of but slightly different composition, which are enclosed in a long tube of porcelain or fire clay. These wires are platinum and an alloy of 90 per cent platinum and 10 per cent rhodium. The action of heat sets up electricity in the wires, forming a thermocouple, and the electric current produced by an increase in temperature is measured by a galvanometer. It measures readily and accurately, temperatures as high as 3,000° Fahr.

When a pyrometer is used, it should be compared with a mercurial thermometer within its range, and if greater accuracy is desired at very high temperatures, it should be compared with an air thermometer, which is the accepted ultimate standard of reference in all high temperature measurements.

Pyrometer, Thermo-electric.—A valuable form of pyrometer utilizing the measure of electromotive forces developed by the difference in temperature of two similar thermo-electric junctions opposed to each other.

Pyrometry.—The branch of science concerned with the measurement of heat.

Q.—Symbol for quantity of electricity; the *ampere hour* or *coulomb*.

q.—1. Symbol for electrostatic charge.

2. Symbol for instantaneous value of quantity of electricity.

Quad.—1. In telegraphy, an abbreviation for quadruplex.

2. An abbreviation for quadrant, a name sometimes used for the *henry*.

Quadmeter.—A term sometimes used for secohmmeter, an instrument devised by Ayrton and Perry for measuring self-induction and mutual induction in an electric circuit.

Quadrant.—1. A name used at one time for the *henry*, because expressed by 10^9 centimeters, which is a length equal to a quadrant of the earth's surface.

2. The quarter of a circle or of its circumference; a sector, arc or angle of 90°.

3. An instrument for measuring the altitude of the sun, consisting of a graduated arc of 90°, with a movable radius for measuring angles on it.

Quadrantal Deviation.—A deviation or error in a ship's compass due to the induced magnetism in the iron of the vessel by the action of the earth's horizontal force, it changes sign in every quadrant; *quadrantal error*.

Quadrant Electrometer.—A form of sensitive electrometer consisting essentially of two pairs of metallic quadrants, above which swings a needle consisting of a thin plate of aluminum. The quadrant electrometer is sometimes made very sensitive so as to measure as low as $\frac{1}{100}$ volt, but it is a very delicate laboratory instrument. It is valuable for measuring differences of potential where no current is flowing or where current is undesirable.

Quadrant Electroscope.—A device for indicating the electric condition of a conductor, consisting of a wooden standard carrying a graduated quadrant or half circle, in the center of which is attached an index of straw terminating in a pith ball. When the whole is electrified the pith ball is repelled from the upright and flies out at an angle indicated on a graduated scale or quadrant behind it.

Quadrature.—If the angle of lag or of lead between two sets of alternating current waves be 90°, or a quarter circle, the waves are said to be in *quadrature* with each other.

Quadripolar Dynamo.—A multipolar dynamo provided with *four field magnet poles*.

Quadripolar Field.—An electromagnetic field produced by four field magnet poles, as in a quadripolar dynamo.

Quadruple Expansion.—In steam engineering, a four stage expansion engine, the steam being successively expanded in four cylinders, thus dividing the temperature range into four stages, and permitting of a higher degree of expansion than in the triple expansion engine. Quadruple engines may be used to advantage, in marine practice, when the initial steam pressure is over 200 lbs. per sq. in.

Quadruplex Balance.—In quadruplex telegraphy, obtaining a *resistance balance* between the artificial line and the main line, and a *static balance* in which the condenser of the artificial line has a capacity equal to that of the main line.

Quadruplex Circuit.—The circuit employed in quadruplex telegraphy.

Quadruplex Connector.—Any means of making an electrical connection with the terminals of four wires.

Quadruplex Re-entrant Armature Winding.—A four path armature winding each of which is re-entrant independently of the others

Quadruplex Telegraphy.—A system of telegraphy by which four messages may be transmitted simultaneously over the same wire, two in each direction; a combination of duplex and diplex telegraphy.

Quadruplex Telephony.—A system of telephony by which four messages may be transmitted simultaneously over the same wire, two in each direction.

Quadruplex Transmission.—The simultaneous transmission of four telegraph or

telephone messages over one wire, two from each end.

Quadruplex Working.—The operation of quadruplex telegraphy or telephony.

Qualitative Analysis.—In chemistry, an analysis which determines what kinds of elementary substances occur in the matter analyzed, without regard to their quantity.

Quality of Sound.—The element which distinguishes notes of the same pitch and equal loudness emitted from different sources; *timbre.*

Quantitative Analysis.—In chemistry, an analysis which determines in what proportions elementary substances occur in the compound analyzed.

Quantity Armature.—A term formerly applied to an armature wound with few coils for low resistance and large quantity of current.

Quantity Connection.—A term formerly applied to electrical connections for producing the largest quantity of current; *parallel* or *multiple connection.*

Quantity Current.—A term applied to the electric current generated by a parallel connected battery.

Quantity Efficiency.—A term used for the *ampere hour* efficiency of a storage battery, referring to the *quantity* of electricity obtained from the battery, found by multiplying the current delivered in amperes by the time in hours the current was maintained.

Quantity, Electric.—The amount of electricity present in a charge, or delivered by a current. The practical unit of electric quantity is the *coulomb.*

Quantity Meter.—An electric measuring instrument designed to record in ampere hours the quantity of electricity passing through a circuit; also known as *coulomb meter.*

Quantivalence.—A term sometimes used in chemistry for *valency* or *atomicity.* The valence of the atomic weight of an element is the number of atomic weights of hydrogen which it combines with or displaces.

Quarter Period.—The time taken to execute one quarter of a cycle of a periodic motion.

Quarter Phase.—A term sometimes used for *two phase* because in a two phase alternating current system the two electromotive forces are 90 degrees or one-quarter of a cycle apart; also called *quadri-phase.*

Quarter Turn Drive.—In belting and shafting, a transmission of power by means of a quarter twist belt.

Quarter Twist Belt.—A method of driving two shafts at right angles to each other and in different planes. The pulleys must be set so that a plumb line from the center of the face of the upper pulley, on the side where the belt leaves it, will touch the center of the face of the lower pulley on the side where the belt leaves it. The direction of rotation must be such that the twisted belt is always "going on" to the upper pulley.

Quartz.—A mineral known as silicon dioxide. Crystalline, transparent to opaque. Pure quartz is colorless, but it is often colored by impurities. It is a widely distributed mineral occurring as a rock constituent and in veins. Pure quartz is used for spectacle lenses under the name pebble, and quartz sand is used for the manufacture of water glass and for other industrial purposes.

Quartz Fiber.—A fine thread produced by rapidly drawing out a piece of quartz when fused in the oxyhydrogen flame. This fiber can be made more slender than any natural fiber, and because of its strength and elasticity is used for delicate suspension in sensitive galvanometers, electrometers, etc.

Quartzose.—Rocks consisting of quartz.

Quartz Thread.—An exceedingly slender filament spun from melted quartz, employed in making torsion suspensions; *quartz fiber.*

Quega.—A prefix to a unit of measurement to denote *one quintillion* times that unit; as, for example, *quegohm.*

Quick Break.—A sudden break in an electric circuit, as by a quick break switch.

Quick Break Switch.—A spring operated switch.

Quicking.—A process in electroplating with silver, employed to secure a perfect adhesion of the metal; it consists in covering the article to be plated with a thin coating of mercury by dipping it in a solution of a mercury salt; also termed *quickening.*

Quicking Liquid or Solution.—A solution of nitrate of mercury, or of some other salt of mercury, into which articles are dipped preparatory to silver plating in order to secure perfect adhesion of the metal.

Quick Lime.—Lime burnt and unslaked; calcium oxide; prepared by burning limestone or marble in kilns to drive off the carbonic acid.

Quicksand.—Sand easily moved or readily yielding to pressure; especially a deep mass of loose or moving sand mixed with water.

Quicksilver.—The metal *mercury*; so called from its resemblance to liquid silver; it is so called on account of its fluidity at normal temperatures.

Quiet Arc.—A normal condition of the arc in an arc lamp, free from noise, as distinguished from a hissing or noisy arc.

Quiet Commutation.—Smooth operation of the armature commutator with freedom from noise and sparking at the brushes; *sparkless commutation.*

Quiet Discharge.—A *convective* discharge. A discharge of static electricity which may take place noiselessly from the tip of a pointed conductor when electricity has accumulated there in considerable density; also called *point discharge.*

R.—Abbreviation for resistance, *ohmic* or *magnetic.*

r.—Abbreviation for *radius.*

ρ—The Greek letter *rho,* the symbol for *specific resistance.*

Race.—In hydraulics, a canal or water course, leading from a dam to a water wheel which it drives; sometimes called the head race, in opposition to the tail race, which is the water course leading from the bottom of a water wheel; a mill race.

Raceway.—A space left in the ducts of an underground conduit to allow of the ready removal or introduction of electric conductors.

Racing of Dynamo.—A burst of speed in the running of a dynamo when suddenly relieved of its load.

Racing of Motor.—A burst of speed in the rotation of a motor when suddenly relieved of its load.

Racking.—The running of the block carriage of a crane, or traveler, inwards or outwards, to adjust it to the requirements of the work.

Racking of Armature Conductors.—A drag sometimes sustained by the coils of a dynamo or motor armature while in operation.

Rad.—A unit of time flux of light equal to a lumen per second; *a lumen second.*

Radiability.—The power of transmitting radiation possessed by radio-active substances.

Radial Brush.—A form of commutator brush in which a block of carbon moving freely in a socket is held directly against the surface of the commutator by a flat spring.

Radial Flow.—A turbine is said to have radial flow when the water flows inwardly from the circumference of the wheel to its center, or outwardly in the reverse direction.

Radially Laminated Armature.—A laminated armature having a core built up of metal discs arranged about a central shaft.

Radial Truck.—A triple form of car truck for use with heavy cars, being so adjusted that it can swivel under the car in turning a curve.

Radian.—The unit employed in measuring angles. It is the angle at the center of a circle that embraces an arc of circumference equal to the length of the radius of the circle.

Radian per Second.—The unit of angular velocity of a moving body constantly changing its direction; the angle swept over per second by a rotating body.

Radiant Efficiency.—The ratio of the luminous radiation of a source of light to the total radiation, both luminous and obscure, emitted by it.

Radiant Energy.—1. Energy transmitted through space at infinite speed by the vibrations of the universal ether.

2. The radiant expulsion of minute particles of matter between electrodes through a rarefied space, as the cathode rays of a Crookes tube, or through the ether from radio-active substances.

Radiant Heat.—Heat waves passing through space with the velocity of light, and giving the sensation of heat only when absorbed by the body through which they are passing.

Radiant Matter.—Matter found to exist in the extremely rarefied gas of high vacua in a fourth state, which exhibits extraordinary properties not known to the solid, liquid, or gaseous conditions; *ultra gaseous matter.*

Radiant Rays.—In physics, these are said to go in all directions, yet act in the most efficient manner when striking a surface exactly at a right angle to their line of movement.

Radiate.—1. To emit rays through the medium of ether vibrations, as light and heat.

2. To expel minute particles of radiant matter, as from radio-active substances.

Radiation.—1. The transmission of energy by ether vibrations.

2. The radiant expulsion of charged particles of matter at high velocity, such as the *alpha, beta* and *gamma* rays emitted by radio-active substances.

Radiation, Electric.—Electric or electromagnetic waves, a series of electric disturbances or waves set up in the surrounding medium by discharges from a condenser. They are also known as Hertzian waves from Hertz, a German scientist who first produced them by sparks from an induction coil.

Radiation of Heat.—Throwing out of heat in rays; the opposite process of absorption. All bodies possess the property of radiating heat. The heat rays proceed in straight lines, and the intensity of the heat radiated from any one source becomes less as the distance from the source increases. This decrease is governed by a natural law, which is this: the intensity decreases in the inverse ratio of the square of the distance; for example, at any given distance from the source of radiation, the intensity of the radiant heat is four times as great as it is at twice the distance. According to Dr. Alfred M. Mayer, the relative radiations from a cube of cast iron, having faces rough, draw-filed, polished, and from the same surfaces oiled, are as follows:

Surface	Oiled	Dry
Rough	100	100
Planed	60	32
Draw-filed	49	20
Polished	45	18

The oiling of smoothly polished castings, such as cylinder heads of engines, according to the table, more than doubles the loss of heat by radiation, while it does not seriously affect rough castings.

Radiation of Magnetic Flux.—Lines of magnetic force projected radially from the positive pole of a magnet.

Radiator.—1. In wireless telegraphy, the aerial wire used for transmitting messages.

2. In automobiles, a tubular or honeycomb device for the purpose of cooling the water that prevents the motor from reaching too high a temperature. Radiators are of quite varied design, the object in each case being to expose as large a surface as possible to the air. The water is carried in a tank slung near the rear or driving axle, is forced by means of a small centrifugal pump through the water jackets, passes to the radiator, and returns to the supply tank once more. Fans or propellers, belt driven from the crank shaft, are frequently employed to assist the radiator, drawing air through it from forward, and discharging over the outside cylinder casing, thus keeping down the temperature inside the bonnet.

Radiator, Electric.—An electric heater in which the heating effect of an electric current passing through resistance coils is utilized for the purpose of warming cars and buildings.

Radiator System.—In wireless telegraphy, the high tension transmission system.

Radical.—1. In chemistry, a group of elements which reacts as if it were a single element; also known as compound radical.

2. An *ion*, one of the products of electrolysis, consisting of a portion of matter carrying a definite electric charge.

Radio-active Substances.—A class of substances, such as uranium, thorium, radium, and their compounds, which possess the property of spontaneously and continuously emitting radiations capable of passing through substances opaque to ordinary light. Three different types of such radiations have been distinguished, known as *alpha* (α), *beta* (β), and *gamma* (γ) rays.

Radio-activity.—That property of a substance by which it spontaneously emits rays which affect a sensitive photographic plate, excite phosphorescence in certain substances, and *ionize* the surrounding air, that is to say, break up the molecules of the air into atoms which become electrical conductors. Evidence shows that radio-activity is a general property of all matter in a higher or lower degree, instead of its being confined to a few extremely rare substances. The phenomena of emission of various minute corpuscles accompanies the breaking up of a supposedly irreducible atom into simpler forms, and observation of these manifestations is altering or modifying the physical conceptions of matter.

Radiograph.—A picture taken upon a photographic plate by means of X-rays, usually of an opaque object through which the rays pass; *an X-ray photograph; a skiagraph.*

Radiography.—The art of making radiographs, or X-ray photographs.

Radiometer.—An apparatus invented by Sir William Crookes which demonstrates

the power of light. A set of metal vanes, blackened on one side and bright on the other, is fixed on a vertical axis, capable of free revolution, within a glass bulb from which the air is exhausted. Radiant heat received by the vanes causes them to rotate at a speed depending upon the intensity of the radiation.

Radio-micrometer.—An extremely sensitive instrument for measuring faint heat radiations, consisting essentially of a closed circuit containing a bismuth-antimony junction suspended between the poles of a powerful magnet.

Radiophone.—An instrument by which sound is produced by the action of radiant energy intermittently brought to bear upon a substance sensitive to it.

Radiophonic Sounds.—Sounds produced in a radiophone.

Radiophony.—The process of producing sound by radiant energy by means of a radiophone.

Radioscopy.—An examination, as of a part of the human body, by the use of the X-ray in connection with a fluorescent screen without employing photography.

Radio-telegraphy.—An approved term for wireless telegraphy. The term is usually applied to long distance transmission of signals by means of electromagnetic waves projected through space without the intervention of insulated conductors between sending and receiving stations. Electric oscillations are generated at the sending station by means of an *oscillator* consisting essentially of a grounded spark gap terminating above in a vertical *antenna* carried upon a mast. These oscillations are projected by the antenna as electromagnetic waves which are caught at a receiving station by an aerial wire, transformed again into oscillations and detected by a sensitive device.

Radio-telephony.—An approved term for wireless telephony. It is the transmission through distance of articulate speech by means of electromagnetic waves without the use of conducting wires between the transmitter and receiver. Its success depends upon the production at the transmitting station of undamped electric oscillations which may be absorbed by a properly syntonized receiving antenna tuned to the wave length employed, and made to affect a telephone receiver so as to reproduce articulate sounds.

Radio-therapeutics.—The treatment of disease by the use of the X-ray.

Radium.—A metal allied to barium, found in minute quantities in a few rare uranium bearing minerals; notably, pitchblende. The metal itself has not been separated but is obtained as a bromide, after most careful and laborious treatment at the rate of about one ounce to 140 tons of pitchblende. Radium is an element whose atom is unstable; that is, it spontaneously breaks up into simpler atoms, the decomposition being manifested as a shower or streams of infinitesimal corpuscles accompanied by the emission of relatively great amounts of energy. The rate of decomposition is such that a grain of radium would last 150 years.

Radius.—A straight line drawn from the center of a circle to any part of its circumference, all lines so drawn being equal in length; the semi-diameter of a circle.

Radius of Gyration.—In physics, the distance of the center of gyration of any figure from its axis of rotation, that is, the distance from its axis of rotation, of that point at which, if all the moving matter were collected, it would obtain equal angular velocity from, and sustain equal resistance to, the force that gives the rotary motion. More plainly termed the *center of inertia*.

Rag Bolt.—An iron pin with barbs on its shank to retain it in its place.

Rail Bond or Joint.—Short pieces of copper wire riveted into the adjoining ends of the rails of an electric railway to preserve the conducting capacity of the tracks serving as a portion of the return circuit; *track bond*.

Rail Bonding.—The use of rail bonds to preserve good electrical connection between the rails of an electric railway track.

Railroad Switchboard.—A switchboard located in the power house of an electric railroad, and connected with the dynamo and feeder terminals.

Railway Circuit.—The electric circuit by which an electric railroad system is operated.

Railway Dynamo.—The dynamo which generates the current for operating an electric railroad system.

Railway, Electric.—A traction system upon rails in which electricity is employed as the motive power. In street railway service, the cars usually carry motors which are driven by current derived from the line through trolleys or, when the conductor is carried underground, connection is made by contact plows through a slot between

the rails. In heavy railway service. the current is obtained from a third rail by a contact shoe or from an overhead line by "pantograph" or "bow" trolleys to motors carried by electric locomotives.

Railway Motor.—An electric motor designed for railway service. It usually has four poles, and is completely enclosed to keep out moisture. The suspension is usually at one end upon the axle and at the other upon a spring, the power being transmitted by single reduction gear. The standard railway motor is the direct current series motor wound for 500 to 600 volts.

Railway Return Circuit.—The circuit of an electric railroad system, completed by using the rails and the earth as a return path for the current.

Railway Return Wire.—A copper wire sometimes placed in the ground between the rails of an electric road, and connected to each rail so as to secure a satisfactory ground return; *return feeder.*

Railway Turn Out.—A side track introduced at certain points in a single track electric road to allow cars, moving in opposite directions, to pass each other.

Rail Welding.—The electric current may be employed for welding steel rails to make the track continuous in street railway systems. The current is obtained from a transformer supplied from a rotary converter connected with the trolley wire. Two pieces of iron are applied, one on either side of the joint, heated by the current to a welding heat and subjected to the pressure of a hydraulic jack.

Rain Gauge.—An instrument for measuring the quantity of rain that falls at any place in a given time. The rain falls into a funnel shaped receiver of exact dimensions, and is led into a collecting tube of smaller dimensions, frequently one tenth the area of the funnel. This magnifies the apparent rainfall tenfold, permitting very exact observations to be made. An overflow attachment is provided occasionally to measure snowfall.

Rake of Poles.—In pole line construction, for electric railways, wooden poles should be set with a rake of 9 to 18 inches away from the street, while iron or steel poles set in concrete require a rake of only 6 to 9 inches. Poles at corners and curves should have a greater rake or be firmly guyed.

Raking Shore.—In erecting, a shore at an acute angle, running directly from the wall which it supports to the sole piece on the ground. An inclined support which is braced against another wall is known as a *raking strut*; a shore which does not go directly to the ground, but bears upon another, is termed a *rider.*

Ramsay, Sir William.—Born 1852. A Scottish chemist, noted for his discoveries of rare gases. Jointly with Lord Rayleigh he discovered *argon* a new constituent of the atmosphere He also discovered other atmospheric gases, *neon*, *xenon* and *krypton*, and the metal *helium*. In 1904 he received the Nobel prise for chemistry. He is the author and translator of a number of important chemical works.

Range Indicating System.—An electric system installed in a war ship for signaling to the guns the range of the enemy as determined by the range finder.

Range of Instrument.—The limits within which a measuring instrument is capable of making accurate measurements.

Rarefaction.—The removal of air or other gases from a closed vessel by the use of an air pump, thereby producing a vacuum to a greater or less degree. In a very high vacuum, the air is so rarefied as to be practically absent.

Ratchet Pendant Burner.—A gas burner which is lighted by means of an electric spark coil operated by a pendant pull.

Ratchet Sprag.—A ratchet around the axle of a motor car, into which a pawl may be dropped for preventing backward motion of the vehicle on a steep hill, when power is off.

Rated Current.—That current which with the rated terminal voltage gives the rated kilowatts.

Rate of Alternations.—Usually machines used for electric lighting work at from fifty to hundred alternations per second. To obtain the latter with a single coil in a single field would require six thousand revolutions per minute. A rapidly alternating current can be easily obtained with a large number of pole pieces; however a disadvantage results from the fact that these pole pieces alternate in polarity and a large percentage of the lines of force leak across between adjacent limbs, instead of passing through the armature core. Sometimes nearly half the lines of force developed by the field magnets are rendered inoperative by leakage in machines with coreless armatures, but the absence of iron in which repeated changes in the direction of the number of lines of force is taking place obviates the loss by eddy currents

and hysteresis, and may often more than compensate for the loss by leakage

Rate of Doing Work.—*Power*, or the amount of work done in unit time.

Rating of Alternator.—An alternator is rated by its output measured either in kilowatts or in kilovolt-amperes, representing the power that the machine can deliver to the load without excessive rise in temperature.

Rating of Lamps.—Certain nominal values attributed to electric lamps with respect to their illuminating power for commercial purposes. A 480 watt arc lamp is rated at 2000 candle power, and a 300 watt lamp at 1200 candles. though these values are much in excess of the spherical candle power of these lamps, but, since for street lighting, the lower hemispherical candle power is solely important, the excessive rating does not greatly misrepresent their practical lighting values.

With incandescent lamps, the mean horizontal candle power is generally accepted in practice as its rating.

Ratio Arms.—The proportionate arms of a Wheatstone's bridge, the two arms whose ratios are known; also called *bridge arms.*

Ratio of Conversion.—The same as the ratio of transformation.

Ratio of Expansion.—The ratio existing between the final and the initial volumes of the steam in a cylinder or series of cylinders. If steam be cut off at $\frac{1}{6}$ of the stroke the ratio of expansion is 6 to 1, or 6. It is the reciprocal of the cut off.

Ratio of Transformation.—In a transformer, the ratio of the number of turns on the primary coil to the number of turns on the secondary, which establishes the relation of the current delivered by the secondary to the voltage impressed upon the primary; also called *ratio of conversion.*

Rat-tail.—In wireless telegraphy, a name given to the wire by means of which the aerial wire is connected with the sending or receiving instruments.

Rawhide Gears.—Pinions and wheels made of hard leather built up in several thicknesses, through which the teeth are cut. They are used to a considerable extent for high speed driving, especially as a first gear of an electric motor; being durable, elastic and noiseless.

Raw Material.—Crude natural products; substances requiring manufacturing processes to utilize them; material partly treated to fit it for further processes; thus, iron ore is the raw material of pig iron; while pig iron is again raw material for wrought iron or castings.

Ray.—1. A beam of light thrown by a luminous body, light emitted in a given direction from any source.

2. The line along which light travels, or more especially, the line or direction of radiant energy.

3 A line along which the disturbance produced by any form of wave motion travels.

Ray, Electric.—A fish, sometimes called the torpedo, having an organ in the back of its head by which it is able to give an *electric shock.*

Rayleigh, John William Strutt, *3rd Baron.*—Born 1842. An English physicist and experimenter in electrical measurements; discoverer, jointly with Sir William Ramsay, of a new gas (1894) which they named *argon.*

Rayleigh's Ohm.—A determination made by Lord Rayleigh, the English scientist, giving 106.21 centimeters of mercury as representing the true ohm.

Rays.—Lines of radiant energy emitted by sources of light and heat, and by radioactive substances.

Reactance.—In an electric circuit, a resistance having self-induction; it is equal to the component of the impressed electromotive force at right angles to the current divided by the current, and is measured in ohms.

Reactance Coil.—A choking coil, a coil of insulated wire of low resistance wound on a laminated core and joined in series with an alternating current circuit to prevent too large a current. A coreless reactance coil consisting of a spiral of a few turns of insulated wire is used to force a lightning discharge through an arrester.

Reactance Factor.—The relation of the reactance to the ohmic resistance of an electric circuit.

Reaction.—1. Any action in resisting any other action or force; movement in a contrary direction, reverse action. In phys-

ics, reverse or return action; the equal and opposite force exerted on a body by the body acted upon; a force acting in opposition to or balancing another force or system of forces; hence, the philosophical truism "action and reaction are equal, but in opposite directions."

2. In electro-therapeutics, the spasmodic contractions in the tissues of the body which occur upon application of an electric current.

Reaction Motor.—A term sometimes applied to the *induction* motor, in which the current is furnished to the *stator* or fixed part only, the rotations of the moving part or *rotor* being brought about by currents induced by the varying field set up by the alternating currents in the stator.

Reaction of Degeneration.—In electro-therapeutics, a gradual failure to respond to treatment shown by diseased tissues which have been subjected to prolonged curative action of electricity.

Reaction of Exhaustion.—In electro-therapeutics, an exhausted state of the tissues of the body undergoing electrical treatment, such that they fail to respond until the strength of the current is increased.

Reaction Telephone.—A form of telephone provided with a coil of fine wire mounted upon the diaphragm, which serves to strengthen the sound effect by causing mutual reaction with the coils of the electro-magnet.

Reaction Turbine.—A type of steam turbine of which the Parsons turbine is an example; this type has no nozzles, the steam flowing from the boiler into the admission space with practically no velocity. From this point it enters the first set of stationary blades and acquires velocity as the pressure decreases. Entering the set of moving blades it expands again, and passing alternately through the fixed and moving blades, continues expanding until it escapes into the exhaust. This type of turbine gets its name *reaction turbine* because the pressure is not the same on both sides of the moving blades.

Reaction Wheel.—A device for illustrating the effect of the discharge of electricity from points. If slender metal needles, radiating from a center like a wheel with their points all bent at right angles in the same direction, be supported upon a pivot and placed upon the positive pole of an electrostatic machine, the force of the electricity discharged from the points acting against the surrounding air will cause the wheel to rotate in a direction opposite to that in which the points are bent. It is often called an *electric fly*.

2. In hydraulics, an enclosed wheel into which water enters under head or pressure and escapes from it tangentially; the force being derived from the reaction of the weight thrown off at the edge of the wheel.

Reactive Circuit.—An alternating current circuit which contains either inductance or capacity, or both inductance and capacity.

Reactive Drop.—The fall of potential in an electric circuit due to reactance.

Reactive Effect.—The effect of reactance upon the electromotive force in an alternating current, causing a retardation of the current.

Reactive Factor.—The ratio of the wattless volt-amperes to the total amperes in an electric circuit.

Reading Distance.—The distance from a source of light at which an ordinary size of reading print can just be read. Employed for the approximate comparison of light sources, such as street lamps when proper photometric measurements are impracticable.

Reading Microscope.—A microscope mounted upon an instrument for making exact measurements in order to enable the observer to read minute divisions of the scale.

Reading Telescope.—A telescope used in connection with a mirror galvanometer for reading the scale.

Reagent.—A chemical that reacts upon a compound; a substance used to effect chemical changes upon a compound for discovering its constituent parts and determining its percentage composition; thus, iodine added to a solution containing starch turns it a beautiful blue; and on adding common salt to a gold and silver alloy, dissolved in nitric acid, the silver is at once precipitated as chloride and its quantity readily ascertained.

Real Cable.—In duplex submarine cable working, the cable proper as distinguished from the artificial or false cable.

Réaumur Thermometer.—A thermometer having its scale divided into 80 degrees between the freezing and boiling points of water, the freezing point being taken as zero. One degree Fahrenheit is equal to $\frac{4}{9}$ of a Réaumur degree. The Réaumur thermometer is used for scientific purposes in the countries of Eastern Europe.

Recalescence.—A sudden check in the process of cooling a bar of iron or steel from

a white heat, when the metal glows more brightly for a short while upon reaching a certain temperature, and then continues cooling. On bringing a piece of iron to a white heat and letting it cool in a dark room, it will cool regularly, the colors fading to a dull red as the temperature falls. When a certain point is reached, about 1000° F., not only is the rate of cooling retarded, but the iron bursts out into a glow as if reheated, before fading again. This recalescence is occasioned by molecular changes in the metal, as iron is magnetic *below* the point of recalescence, non magnetic *above* that point.

Recalibrate.—To ascertain anew the variations in the readings of an instrument for electrical measurement, after they have once been calibrated.

Received Current.—In telegraphy, a current received over a line from another station.

Receiver.—1. In telephony, the instrument which is applied to the ear in receiving a message; it consists essentially of a hard rubber shell containing a permanent bar magnet with a thin iron diaphragm in close proximity to one of its poles.

2. In automatic telegraphy, a special recording machine which registers messages as received.

3. A chamber between the cylinders of compound engines into which the steam from the high pressure cylinder escapes, and from which it is admitted to the low pressure cylinder.

Receiving End of Line.—In telegraphy, the end of the line at which a message is received, as distinguished from the sending end.

Receiving Magnet.—The magnet employed in the receiving instrument of a telephone or telegraph line.

Receiving Signaler.—A telegraph operator in the act of receiving a message.

Receptacle.—A wall socket for an incandescent electric lamp.

Receptive Devices.—Electro-receptive devices; any instrument or appliance which receives electrical energy to utilize it, or transform it or measure it.

Receptor.—The general name for the receiving apparatus in wireless telegraphy.

Reciprocal.—In mathematics, the quotient arising by dividing unity by the number whose reciprocal is required.

Reciprocating Motion.—In mechanics, the act, process or state of changing place or position alternately forward and backward.

Reciprocating Motor.—An early type of motor whose armature acted with a reciprocating instead of rotary motion; a *pulsating motor*.

Recoil Circuit.—That portion of a circuit lying in the alternative path of a disruptive discharge.

Recoil of Disruptive Discharge.—A sudden reaction which occurs simultaneously with a disruptive discharge, like the "kick" of a gun.

Recorder.—In telegraphy, an instrument for automatically recording a message as received.

Recorder Ammeter.—An ammeter that automatically records the number of amperes passing through a circuit.

Recorder Battery.—The battery which supplies the current for the operation of a telegraph recorder.

Recorder Coil.—The delicately suspended coil of fine wire that hangs between the poles of the electromagnet in a siphon recorder.

Recorder Magnets.—Electromagnets employed in telegraph recorders.

Recorder Shunt.—A low resistance shunted across the terminals of a siphon recorder.

Recorder Signals.—Telegraphic signals registered upon the paper ribbon in a siphon, or other recorder.

Recorder Switch.—A two-way switch employed in connection with a siphon recorder.

Recorder Tape.—A paper ribbon upon which telegraphic signals are recorded in a siphon, or other recorder.

Recorder Vibrator.—An electromagnetic device for giving a continual vibratory motion to the siphon of a telegraphic recorder, in order to avoid friction as it ejects ink upon the paper ribbon.

Recording Compass.—A variety of mariner's compass designed to record the ship's

direction, and to give a warning signal when the vessel deviates from its course.

Recording Drum.—In an electric chronograph, a rotating cylinder or drum upon which the stylus makes the record.

Recording Thermometer.—A metallic thermometer in which the expansion or contraction, due to heat, actuates an arm carrying a pen, which traces a line corresponding to the fluctuations of the temperature, upon a specially ruled roll of paper driven by clock work.

Recording Voltmeter.—A form of voltmeter designed to register the voltage measured by it. The leverage of a glass pen provided with an ink reservoir is connected by a spring to the movable part of the voltmeter. The movement of the pen as the voltage changes traces a record upon a sheet of paper fed forward by a rotating cylinder.

Recording Wattmeter.—A watt-hour meter, a form of wattmeter designed to register the watt-hours expended during a period of time. It is used to record the amount of electric power furnished to a consumer by a central station. The Thomson recording wattmeter is a small motor without iron in its working parts. Its armature, or revolving part, acts as a pressure coil and its magnetizing windings as a current coil. The driving torque, which tends to make the armature rotate is proportional to the product of the two magnetizing effects and to the watts in the circuit. A series of dials record the consumption of energy in watt-hours.

Recovery of Condenser.—The return of the dielectric of a condenser to its neutral condition after being subjected to the strain of an electric charge.

Rectangular Curve.—A characteristic curve approaching the form of a rectangle.

Rectangular Typ of Alternating Electromotive Force.—The characteristic curve of an alternator, in which the variations of the electromotive force are represented by a curve approaching a rectangle in form.

Rectification of Alcohol, Electric.—A method of purifying alcohol by passing a current of electricity through it between zinc electrodes; the water present is decomposed, the hydrogen combining with the alcohol and the oxygen with the zinc.

Rectified Currents.—Alternating currents which have been acted upon by a rectifying commutator, and changed into direct pulsating currents; *redressed currents.*

Rectifying Commutator.—A form of commutator for obtaining direct pulsating currents from alternating currents; also called *rectifier.*

Rectilinear Current.—An electric current passing along a straight conductor.

Red Brass.—In metals, an alloy variously composed; as, (a) copper, 24 lbs.; zinc, 5 lbs.; bismuth, 1 oz.; (b) copper, 24 lbs.; zinc, 5 lbs.; lead, 8 oz.; (c) copper, 32 lbs.; zinc, 10 lbs.; lead, 1 lb.; (d) copper, 160 lbs.; zinc, 50 lbs.; lead, 10 lbs.; antimony, 44 ozs.

Red Candle.—A standard candle screened by red glass for use in connection with a photometer.

Red Heat.—The degree of heat which causes a metallic body to glow with a reddish light.

Red Lead.—Minium, a bright red and very heavy powder prepared by exposing litharge (lead monoxide) to the air for a long time at a faint red heat. It is employed as an active material in pasted plates of storage batteries, and as a cement for joints in automobiles.

Red Pole.—The north seeking pole of a magnet or magnetic needle, also known as the *N*, *plus*, *positive*, *marked*, or *boreal* pole.

Reduced Battery.—In quadruplex telegraphy, the short end or smaller portion of the divided battery.

Reduced Deflection Method.—A method of electrical measurement based upon observing reduced deflection of the galvanometer needle as the current strength lessens.

Reducing Coupling.—A joint designed to make electrical connection between the ends of two conductors differing in size.

Reducing Switch.—A switch designed to reduce the current furnished to a branch circuit.

Reducing Transformer.—A transformer used to reduce the electromotive force of

an electric circuit, usually called a *step-down transformer.*

Reducteur for Ammetor.—A resistance coil connected in parallel with the coils of an ammeter to act as a shunt to reduce the current entering the ammeter.

Reducteur for Voltmeter.—A resistance coil connected in series with the coils of a voltmeter for the purpose of diminishing the currents in a fixed proportion, and thereby increasing the range of the voltmeter.

Reduction Gearing.—In electric traction, a gearing by which the armature shaft of a motor is connected with the axle of a car, so that there shall be a reduction to one-tenth or one-twelfth of the armature speed at the axle.

Reed Interrupter.—A device for automatically making and breaking a circuit by a vibrating reed; a *tuning fork interrupter.*

Reel Insulator.—A reel shaped insulator employed with certain signal systems.

Re-entrant Armature Windings.—Armature windings in which both ends re-enter or lead back to the starting point.

Re-evaperation.—In steam engineering, a term used to express the influence of an unjacketed engine cylinder in which steam is worked expansively. The cylinder being subject to the extremes of temperature of the entering and exhausting steam, the former is subject to *initial condensation* on its first entrance. The heat thus lost is, however, re-imparted to it, as it acquires by expansion a temperature below that of the cylinder, while towards the end of its work it acquires from the cylinder, hotter than itself, a vaporous condition, or is re-evaporated. By the use of the steam-jacket, these variations are prevented or minimized.

Refining, Electric.—The application of electro-metallurgy in the refining of metals, especially copper, by electrolysis.

Reflecting Galvanometer.—The mirror galvanometer. An instrument for exact determinations, having a small magnetic needle fixed to a very light mirror and suspended inside a coil of wire by means of a silk or quartz fiber, the movements of the needle being indicated by reflection upon the mirror. In one method, the deflections are read by means of a small telescope through which the reflected divisions of a scale are seen on the mirror as it moves; in another, a beam of light is thrown on the mirror and reflected to a suitable scale where the movements of the needle are indicated and magnified.

Reflection.—The change of direction experienced by a ray of light, or of other radiant energy, when it strikes a surface and is thrown back or reflected.

Reflector.—A polished surface of reflecting material designed to reflect light with increased illuminating power.

Reflector Bracket.—A street lamp bracket provided with supports for two insulators and a reflector.

Reflector Shade.—A shade lined with reflecting material for use with an arc lamp.

Reflux Valve.—In hydraulics, a flap valve used for the purpose of taking off the pressure of a head of water, acting in a backward direction against a set of pumps.

Refraction.—1. The change of direction which a ray of light undergoes upon entering obliquely a medium of different density from that through which it has been passing.

2. The change in direction of the flow of an electric current when it passes from one medium to another of different conductivity or of other differing electric qualities.

Refractive Index.—When a ray of light passes obliquely from one medium into another of different density, the ratio between the sines of the incident and refracted angles is known as the refractive index or index of refraction of the second medium with respect to the first.

Refractories.—For lining electric furnaces there are three kinds of refractory materials employed: *acid* in which the chief constituent is silica; *basic* consisting of lime, magnesia, bauxite and dolomite; and *neutral* such as fire clay, chromite and carbon.

Refractory.—A term applied to substances that are infusible, such as fire clay, lime, carbon, etc., or to metals which can be melted only at extremely high temperatures.

Refreshing Action.—In electro-therapeutics, a restored action of fatigued

muscle or nerve tissue produced by the application of *voltaic alternatives.*

Regenerated Cell.—1. A primary cell which has been depolarized after polarization.

2. A storage cell which has been recharged after exhaustion.

Regeneration.—1. The act of restoring an exhausted storage battery to a renewed working condition. It consists in passing an electric current through the battery in a direction opposite to that of the current the battery produced.

2. Restoring a primary cell to activity after it has become polarized.

Regenerative Cell.—A primary or storage cell that may have its energy restored after becoming inactive.

Regional Magnetic Disturbances.—Disturbances in the earth's magnetism confined to limited areas or special regions.

Register, Electric.—Any mechanism for making a permanent record by the aid of electricity.

Registering Barometer.—A self registering device for recording variations in the pressure of the atmosphere. The expansion or contraction of the corrugated cylinder of an aneroid is transmitted by gearing to a needle arm carrying a pen or pencil which moves across a paper coiled on a clockwork driven drum.

Registering Declinometer.—A declinometer which automatically records variations in the earth's magnetic declination.

Registering Electrometer.—An electrometer which automatically records the differences of potential it measures.

Regnault's Law.—Regnault determined by experiment, *that the specific heat at constant pressure is constant for any gas.*

Therefore, if C_p represent the specific heat at constant pressure, and C_v the specific heat at constant volume, and a unit mass of gas be heated at constant pressure P from absolute temperature T_1 to absolute temperature T_2; then

$C_p\,(T_2—T_1)$ = Heat absorbed............(*g*)

Now, if V_1 be the volume of the gas at T_1 and V_2 the volume at T_2: then

$P\,(V_2—V_1) = d\,(T_2—T_1)$ = External work performed (*h*), in which *d* is a constant that depends upon the specific density of the gas and on the units in which P and V are measured: and the difference between the quantities (*g*) and (*h*), or $(C_p—d)\,(T_2—T_1)$ represents the increase in the amount of the internal energy of the gas when its temperature is raised from T_1 to T_2.

Regulating Box.—A term sometimes applied to a resistance box or rheostat.

Regulating Compound Dynamos.—A carefully compounded dynamo will, when run at the speed for which it was designed, regulate itself perfectly, and maintain a constant difference of potential at its terminal under any variation of load within its range. In practice, however, it is not always possible to work a dynamo under these exact conditions, and, moreover, in the case of large machines, the effect of temperature upon the resistance of the machine has an appreciable effect upon the voltage.

Means for regulating the latter are desirable. The voltage may be varied to a certain extent by suitably adjusting the governor of the driving engine, increasing or decreasing the speed; but in many cases this is not very desirable or possible, and a much better method of obtaining the desired variation of voltage is to insert a variable resistance or hand regulator in the shunt circuit of the machine, the resistance of the shunt being suitably proportioned to give the requisite margin for regulation.

Regulating Over-compounded Dynamos.—It is sometimes desirable, as in central light and power stations, to have a dynamo which will maintain a constant pressure at a point some distance from the machine. In this case the dynamo is over-compounded, or the series coils are wound with a greater number of turns, in order to raise the pressure at the terminals of the machine as the load increases, and thus compensate for the fall of pressure in the mains.

As it is well to vary the degree of over-compounding, the series coils of such dynamos are usually so proportioned as to give from 10 per cent to 20 per cent of over-compounding, and a strip or ribbon of German silver or copper is arranged as a shunt to the series coils.

Regulating Relay.—A device for regulating the condition of a main electric circuit by means of control devices actuated by a secondary circuit. Its purpose may be to maintain at a constant value either the voltage, current, frequency, or power factor of the circuit.

Regulating Shunt Dynamos.—In regulating a shunt dynamo, the resistances of the field magnet shunt windings and of the regulator coils are so proportioned, that when no load is on the dynamo, and all the coils of the regulator are in circuit with the shunt, the machine generates the normal pressure required at the lamps. As more and more lamps are switched on, the voltage at the lamps has a tendency to decrease, and therefore the pressure at the machine must be raised in propor-

tion. This is effected by moving the lever of the regulator, so that fewer resistance coils are included in the shunt circuit; the resistance of the latter being thus decreased, the exciting current and voltage of the machine is increased correspondingly.

Regulating Socket.—An incandescent lamp socket containing a resistance coil controlled by the key, for the purpose of regulating the brilliancy of the light.

Regulating Wires.—In pole line construction, adjusting the tension of wires, or regulating the proper sag between the poles.

Regulation.—An electric generator may be required to deliver at a certain speed, an E. M. F. which is within a specified percentage of a constant value when the load is varied. This is called its *regulation*. The definition given by Standardization Committee of the American Institute of Electrical Engineers is as follows: The regulation of a machine or apparatus in regard to some characteristic quantity (such as terminal voltage, current or speed) is the ratio of the deviation of that quantity from its normal value at rated load to the normal rated load value.

Regulation of Dynamo.—Causing a dynamo to operate so that it shall either (1) regulate itself so as to send a constant *current* through an external circuit having varied resistance; or, (2) maintain a constant *potential* difference at its terminals under variations of resistance.

Regulation of Motor.—Controlling the action of a motor so that it shall maintain a uniform speed, whatever its load may be.

Regulator.—1. In storage battery practice employing a shunt wound booster, a device provided to automatically vary the magnitude and direction of the current in the shunt winding according to the load. This "regulator" consists essentially of a carbon resistance composed of piles of carbon discs in which the pressure may be varied, and a pressure producing coil and plunger.

2. Any automatic or hand device for regulating a dynamo or motor; especially an electromagnetic device actuated by solenoids placed in the main circuit for automatic regulation.

Regulator Magnet.—An electromagnet sometimes employed in the regulation of direct current dynamos to automatically shift the rocker carrying the brushes upon the commutator as the load varies, so that a constant current may be maintained.

Reguline.—In electro-metallurgy, a term applied to metallic deposits which have all the characteristics of the pure metal.

Reheater.—In a compound engine, a receiver between the high pressure and low pressure cylinders, so constructed that the exhaust from the high pressure cylinder is reheated before entering the low pressure cylinder by live steam from the boiler. Sometimes called *reheating receiver*.

Reinforced Concrete.—A cement concrete reinforced by steel bars and rods disposed through its mass in such a manner, that tensile stresses are borne by the steel, which possesses great tensile strength, while compressive stresses fall upon the concrete itself, which is strong in compression but weak in tension. Also known as *armored concrete*, etc.

Reinforced Sound.—Sound intensified by means of a sounding box, sounding board, or similar agency.

Rejuvenation of Luminescence.—Restoring luminescence to a substance which has exhausted its capacity for spontaneous glowing.

Relations of Temperature, Volume, and Pressure.—In conformity with the laws of permanent gases, the mutual relations of the temperature, volume, and pressure of a gas in the cylinder of an engine vary according to the conditions which obtain at heating.

1. *If the temperature of the gas is kept constant, an increase of volume results in a decrease of pressure (Boyle's Law).*
2. *If the pressure of the gas is kept constant, an increase of temperature results in an increase of volume. (Gay-Lussac's Law.)*
3. *If the volume of the gas is kept constant, an increase of temperature results in an increase of pressure (Gay-Lussac's, Regnault's, and Joule's Laws).*

Relative Inductivity.—The specific inductive capacity of a substance. It is measured by the ratio of the capacity of a condenser which has its plates separated by that substance to the capacity of the same condenser when its plates are separated by dry air.

Relay.—1. A device for opening or closing a local circuit under given conditions in the main circuit.

2. In telegraphy, an auxiliary electromagnet which receives the current from the line, and is thereby actuated to open and close the circuit of a local battery, and furnish to the receiver a current of requisite strength.

3. A telephone repeater, in which a microphone is acted upon by the receiver of the first line cir-

cuit so as to introduce a local circuit which, in turn, acts inductively on the second line wire.

Relay Bell.—An electric bell which is rung by the action of a relay magnet which introduces a local battery into the circuit.

Relay Contact.—An electromagnetic mechanism which completes a local circuit when a current is passed through it.

Relay Magnet.—The permanently magnetized steel armature of a polarized relay.

Release.—In steam engineering, the point on an indicator diagram, denoting where the valve has opened to exhaust, before the completion of the power stroke. Strictly speaking, the period from the opening of exhaust until the end of the stroke is called *pre-release;* the remaining period of exhaust till the beginning of compression is called *release.*

Relief Lamp.—1. A series incandescent lamp provided with an automatic cut out which short circuits the lamp the moment it breaks.

2. A lamp reserved for immediate substitution for a broken lamp.

Relief Operators.—Telegraph or telephone operators whose duty it is to relieve the regular operators

Relievo.—An electro or die with the design raised above the surface; a carving in relief, as distinguished from an *intaglio.*

Reluctance.—The resistance offered to the magnetic flux by the substance magnetized, being the ratio of magnetomotive force to the magnetic flux; *magnetic resistance.* Its unit is the *oersted,* and its symbol is R.

Reluctivity.—The resistance per unit of length and unit cross section that a substance offers to being magnetized; *specific magnetic resistance.*

Remanence.—The property possessed by a magnetizable substance, as iron or steel, of retaining a portion of its magnetism after the magnetizing force has been removed.

Remanent Flux or Magnetism.—Residual magnetism, the magnetism which is retained by iron or steel after it has been magnetized and the magnetizing force has ceased to act upon it.

Remote Control Switch.—A switch operated from a point at a greater or less distance from the switch itself by mechanical or electrical means.

Remote Control Switchboard.—One in which the main current carrying parts are at some distance from the controlling and measuring apparatus. This form of switchboard may be operated by hand or by electric power or sometimes by compressed air.

Renovation of Storage Cell.—The renewing of an electric charge in an exhausted storage cell; *recharging.*

Repair Outfit.—A kit of tools, cements and materials, necessary to effect repairs on such things as leather or rubber belting, pneumatic tires and similar fabrics

Repair Part.—A duplicate portion of a mechanism carried to replace a detail which may break or give away in service.

Repair Wagon.—A tower wagon, or specially constructed vehicle carrying an elevated structure so that workmen can readily reach the trolley line to repair it.

Repeater.—In telegraphy, an arrangement of electrical instruments and apparatus for repeating a message coming over one line to go forward over another line by the aid of a separate battery. An automatic type repeats in either direction without requiring the turning of a switch. By means of repeaters, the reception and re-transmission of a message by the operator at an intermediate office on a long line is dispensed with.

Repeating Coil.—In telephone work, a special form of induction coil designed to connect a grounded line with a metallic line. Repeating coils were formerly constructed on the principle of the Faraday ring, which consists of a coil of iron wire for the core with a bobbin carrying the primary winding on the one side and another carrying the secondary on the opposite side. Such an instrument is still known as the standard repeating coil, as generally used by the Bell companies. Later practice, however, has given birth to the armored coil, which is enclosed in a suitable iron sheath, with the primary object of neutralizing stray currents and inductive influences from the outside by a magnetic envelope, and also of preventing similar influences from the coil itself upon outside apparatus. It consists essentially of a primary and secondary coil wound upon a core consisting of a bundle of soft iron wires the ends of which are bent around outside the coil forming a casing of wire, or the coil is enveloped in an annealed iron tube, closed at both ends and connected to the core.

Repeating Relay.—A relay employed in a telegraphic repeater to take a message from one wire and transmit it automatically to another wire.

Repeating Sounder.—A telegraphic sounder which assists in repeating a message into another line.

Repeating Telegraphic Station.—In a long telegraph line, an intermediate station in which messages are received from one wire and re-transmitted automatically into another by means of telegraphic repeaters.

Replenisher.—A form of static influence machine designed to maintain constant the potential of the needle of the quadrant electrometer.

Repose.—To cause to stop or rest after motion. In physics, the *angle of repose* is the inclination of a plane at which a body placed on the plane, would remain at rest, or, if in motion, would roll or slide down with uniform velocity; the limiting angle at which the various kinds of earth will stand when abandoned to themselves.

Repulsion.—1. The act or effort of forcing back; driving in the opposite direction, causing to recede.

2. A physical force which compels certain bodies or their particles to recede from each other; the reverse of attraction.

Repulsion, Electric.—The action of a force by which two similarly charged bodies tend to repel each other.

Repulsion Electrometer.—An instrument which measures differences of electrostatic potential by employing the principle of electric repulsion.

Repulsion, Magnetic.—The action of a force by which two magnetic poles of the same kind repel each other.

Repulsion Motor.—A type of single phase motor which has a considerable starting torque. Such motors are rarely found in use because of commutation difficulties and their so-called *series* characteristics.

Requisites.—Those things which are so necessary that they may not be dispensed with. A *requisite* differs from a *requirement* in that the latter signifies what is required of or by a person, while the former conveys the idea of something material or to be possessed, in view of the nature of the case.

Reserve Cell Switch.—A switch connected with a storage battery for the purpose of maintaining a constant rate of discharge by introducing reserve cells.

Residual Atmosphere, or Gas.—Traces of gaseous matter which remain in a vacuum, though exhaustion may have been carried to the highest degree possible by any known mechanical means.

Residual Charge.—A residue of electrification retained by a Leyden jar after a discharge; *electric residue*; *soakage.*

Residual Magnetic Flux.—The residue of magnetic flux retained by a body because of the power of magnetic remanence after the magnetizing influence is withdrawn.

Residual Magnetism.—1. The magnetism retained by the core of an electromagnet after the circuit has been broken. When a mass of iron has once been magnetized, it becomes a difficult matter to entirely remove all traces when the magnetising agent has been removed, and, as a general rule, a small amount of magnetism is permanently retained by the iron. This is known as *residual magnetism*, and it varies in amount with the quality of the iron. Well annealed, pure wrought iron, as a rule, possesses very little residual magnetism, while, on the other hand, wrought iron, which contains a large percentage of impurities, or which has been subjected to some hardening process, such as hammering, rolling, stamping, etc., and cast iron, possess a very large amount of residual magnetism. This property of residual magnetism in iron is of great importance in the working of the *self-exciting* dynamo, and is, indeed, the essential principle of this class of machines.

2. The small residue of magnetism retained by soft iron after the removal of the magnetising force.

3. The comparative large amount of magnetism held by a mass of hard steel, resulting in the so called permanent magnet.

Resilience.—The act or quality of elasticity as understood by physicists; the property of springing back or recoiling upon removal of a pressure, as with a spring. Without special qualifications the term is understood to mean the work given out by a spring, or piece, strained similarly to a spring, after being strained to the extreme limit within which it may be strained again and again, without rupture or receiving *permanent set.*

Resin.—A class of vegetable products obtained from the sap of certain trees, especially the residue from distillation of

pitch. Resin in its various forms is a dielectric, and is useful for insulating purposes.

Resinous Electricity.—The kind of electricity produced upon a resinous substance such as sealing wax, resin, shellac, rubber or amber when rubbed with wool or fur, as distinguished from *vitreous* electricity produced by rubbing glass with silk. Resinous electricity is also called *negative electricity*.

Resinous Electrification.—A negative electric charge, the kind of electricity with which a stick of sealing wax, resin, amber or other resinous substance becomes charged when rubbed with wool or fur.

Resist.—In mechanics, a coating of any kind applied to a surface to protect it from corrosion or the action of other chemical agents.

Resistance.—1. That property of a substance that opposes the flow of an electric current through it. Ohm's law states that the strength of a current due to an electromotive force falls off in proportion as the resistance in the circuit increases. It is therefore possible to compare two resistances with each other by finding out in what proportion each of them will cause the current of a constant battery to fall off.

Silver is taken as the standard, with the percentage of 100, and the conductivity of all other metals is expressed in hundredths of the conductivity of silver. The practical unit of electrical resistance is the *ohm*.

2. In physics, the quality of not yielding to force or external pressure; that power of a body which acts in opposition to the impulse or pressure of another, or which resists the effect of another power; as, the resistance of the air to a body passing through it; the resistance of a target to a projectile.

The following table gives the relative conductivities of different metals at 0° and 100° Centigrade. (Matthiessen.)

METALS	CONDUCTIVITIES	
	At 0° C	At 100° C
Silver, hard	100.	71.56
Copper, hard	99.95	70.27
Zinc, pressed	29.02	20.67
Platinum, soft	18.	...
Iron, soft	16.8	...
Lead	8.32	5.86
Mercury, pure	1.245	.878

Resistance Balance.—In duplex and quadruplex telegraphy, a balance of the circuit obtained by placing, by means of a rheostat, a resistance in the artificial line equal to that in the main line, the distant relays and battery.

Resistance Box.—A box containing sets of standard resistances consisting of spools of insulated wire having low conductivity and small temperature coefficient, employed for the purpose of electrical testing or for introducing a variable resistance into a circuit; also called a *regulating box* or *rheostat*.

Resistance Bridge.—A term sometimes applied to the Wheatstone bridge; a device for comparing electric resistances in which two resistances whose ratio is known are used to compare two other resistances one of which is unknown. A galvanometer is "bridged" between the two sets of resistances.

Resistance Bridge Box.—A form of Wheatstone's bridge contained in a box.

Resistance Coefficient or Factor.—The specific resistance of a substance. It may be taken as the electric resistance of a piece of that substance 1 cm. in length and 1 sq. cm. cross section, at a temperature of 32° F. or 0° C.

Resistance Coil.—A coil of wire of German silver or similar alloy, having a known electrical resistance, employed in a resistance box or rheostat.

Resistance Column.—A resistance obtained by introducing variable lengths of a column of mercury into a circuit.

Resistance, Electric.—The resistance offered by a conductor to the passage of electricity; it is measured in *ohms*.

Resistance Frame.—A form of hand regulator for the regulation of dynamos, consisting of two hollow cast iron end frames with slate slabs fitted into them, the latter carrying resistance spirals of German silver wire joined in series and controlled by a contact switch.

Resistance Losses.—In electrical systems, loss of energy due to resistances opposed to the flow of the electric current.

Resistance of Human Body.—The resistance offered by the human body to the passage of electricity through it.

Resistance of Leakage.—In telegraphy, a resistance in the circuit due to a leak in the line.

Resistance of Voltaic Arc.—A resistance which an electric arc offers to the current, causing a drop of potential in the neighborhood of the crater.

Resistance Slide.—The sliding contact of a rheostat which cuts in or out of circuit the several resistance coils.

Resistance Temperature Coefficient.—In a metal, the ratio of increase in specific resistance, or resistivity, corresponding to an increase in temperature of one degree.

Resistance Thermometer, Electric.—A thermometer which depends for its action upon the changes of electrical resistance in a metal under variations in temperature.

Resistance Wire.—A wire composed of some special alloy, usually German silver, employed in making resistance coils. A frequent composition of German silver for this purpose is as follows: 50 parts by weight of copper, 30 parts zinc, and 20 parts nickel.

Resister.—In submarine cable laying, a buoy employed to relieve the tension of the cable as it is paid out.

Resistivity.—The resistance in ohms of a centimeter cube of a substance to a flow of electric current between opposite faces; *specific resistance.*

Resistivity per Meter Gram.—The electric resistance of a piece of substance one meter in length, of uniform cross section, and having a mass of one gram.

Resolution of a Force.—In physics, the process of discovering the magnitude and direction of two or more forces so that their resultant is identical with the force which is being resolved. It is the antithesis of *composition* of forces, for instead of finding the single force which is the resultant of several, it finds out the various *components* of a given resultant.

Resolvent.—Anything which has power to reduce something else to a state of solution.

Resonance, Electric.—A phenomenon observed in alternating current circuits when capacity and inductance are present together. An abnormal rise of current or voltage occurs in a part of the circuit, much in excess of the values supplied by the generating source. It is due to the neutralising effect of capacity and inductance acting one upon the other. An electrical circuit is said to be in resonance with an impressed pressure, when the natural period of the circuit is equal to the period of the impressed pressure.

Resonant Capacity.—The capacity of an alternating current circuit which tends to produce electrical resonance.

Resonant Circuit.—1. An alternating current circuit containing inductance and capacity in such relations as to produce electrical resonance.

2. A circuit of such a character as to awaken sympathetic pulsations or vibrations in an adjacent circuit.

Resonant Inductance.—The inductance of an alternating current circuit which tends to produce electrical resonance.

Resonant Rise of Potential.—The increase of electrical potential in a resonant circuit.

Resonator.—1. A device employed by Hertz in his experiments with electromagnetic waves in order to detect the waves started by the spark gap of his oscillator. It consisted simply of a circle of wire containing a spark gap capable of fine adjustment. When the waves passed through this ring, electrical vibrations occurred in it which were revealed by small sparks passing across the air gap.

2. In wireless telegraphy, the aerial wire and high frequency circuits of the receiving system.

Responder.—In the De Forest system of wireless telegraphy, an electrolytic receiving instrument consisting of a mixture of litharge, glycerine and alcohol, carrying fine tin filings and filling a gap between electrodes; the current from the local battery normally causes a metallic conducting bridge to be formed through the mixture, while the passage of an electric wave from the opposite direction destroys this conducting bridge by electrolysis and breaks the local battery circuit, giving the signals.

Restored Cell.—A recharged cell.

Restoring Coil.—An electromagnetic coil for operating a self-restoring telephone switchboard drop.

Restoring Coil Battery.—A battery in a telephone exchange for the operation of self-restoring switchboard drops.

Restoring Coil Circuit.—A local circuit in a telephone exchange containing a bat-

tery for operating self-restoring switchboard drops.

Resultant.—In mechanics, the sum of two or more separate forces which act upon a body in different directions, not equal and opposite, causing it to move, or producing a tendency to move in a definite direction. In other words, it may be defined as a single force which replaces two or more other forces, and which is *equal to their sum.*

Resultant Induction.—A magnetic induction which is the resultant of various forces tending to produce induction.

Resultant Magnetic Field.—A line, whose direction may be determined by the "parallelogram of forces," indicating the resultant of the magnetic forces in a magnetic field.

Resultant Magnetic Field of Dynamo.—The resultant of magnetic fields generated by the armature and field magnets; its direction depending upon the relative magnetizing forces of the two.

Resultant Reactance.—The sum of all the reactances existing in an electric circuit.

Resuscitating Power of Storage Cell.—The power which a storage cell has of renewing its activity when recharged after exhaustion.

Retaining Wall.—A masonry wall erected to retain the sides of an excavation if steeper than the angle of repose of the soil, or should the slope be made of treacherous soil.

Retardance.—In a telephone circuit, a quantity equal to the total capacity of the line multiplied by the total ohmic resistance.

Retardation.—1. The tendency of electromagnetic inertia, or self-induction, to prevent an electric current from beginning or ceasing instantaneously in a circuit.

2. In telegraphy, the delay in the transmission of signals over long lines, especially in submarine cables, due to the electrostatic capacity of the line.

3. In mechanics, a decrease of velocity or speed of movement on the part of anything, either from internal causes or from being hindered in its free progress.

Retarder.—In a steam boiler, a spirally curved lath of metal placed in the fire tubes to check the speed of the gases, and cause them to part with more of their heat.

Retarding Disc.—A copper disc mounted upon a shaft so that it retards its own speed of rotation by cutting lines of magnetic force.

Retarding, or Retardation Coil.—A choking coil, a device used in alternating current circuits as resistances are used on direct current circuits, but without causing waste of power. It is usually a coil of insulated wire of low resistance wound on a laminated core and joined in series with the circuit to prevent too large a current.

Retentiveness.—That property of magnetizable substances which is measured by the residual magnetism.

Retentivity.—The power to hold residual magnetism, as shown by a magnetizable substance in its resistance to magnetization or demagnetization. Not all magnetic substances can become magnets permanently. Steel lodestone and nickel permanently retain the greater part of the magnetism imparted to them Steel is magnetized with more difficulty than iron but retains the magnetism better than the latter. The power of resisting magnetism is called *coercive force.*

Retort Carbon.—An impure carbon deposited in coal gas retorts, formerly employed for the manufacture of arc lamp carbons.

Return Call Annunciator.—An annunciator drop in an answering call box, which indicates that a call has properly reached the station.

Return Circuit.—That portion of an electric circuit through which the current is assumed to return to its starting point.

Return Current.—In telegraphy, the current flowing back to the sending station to be discharged to earth.

Return Feeders.—In electric traction, feeders sometimes laid alongside the rails and connected to them at intervals for taking back portions of the return current; railway return wires.

Return Ground.—The ground return. The earth or ground used as a return in an electric circuit employing only one wire, the terminal being connected to water or gas pipes or to iron rods driven into the ground.

Returns.—Those conductors in an electric system which form the paths for the return of the current to its starting point after supplying the circuit.

Return Shock.—1. A shock, due to electrostatic induction, which may be felt in the neighborhood of a charged conductor when suddenly discharged; the return charge.

2. On the same principle, a violent shock sometimes experienced at a considerable distance from the place where a discharge of lightning occurs, caused by inductive action of the cloud upon bodies within its range.

Return Wire.—That conductor in an electric circuit through which the current returns to its starting point.

Revealer.—In wireless telegraphy, a term sometimes used for *detector*, the device which detects or reveals the arrival of electromagnetic oscillations.

Reversal of Polarity of Dynamos.—When compound or series wound dynamos are running in parallel, their polarity is occasionally reversed, while stopping, by the current from the machines at work. Under such conditions, when the machine is again started, the E. M. F. of one is added to that of another, or the machines are connected in series, so that a closed circuit is formed, and as a consequence an enormous current results. Before the machine can be again coupled in parallel, it will be necessary to send a current through the field coils in the reverse direction.

Reversals.—In duplex and quadruplex telegraphy, changes in the polarity of the battery which produces changes in the direction of the current and in the magnetism of the relays.

Reverse Currents.—Currents changed in direction for the transmission of signals in duplex and quadruplex telegraphy.

Reverse Current Working.—In duplex and quadruplex telegraphy, the use of reverse currents for the transmission of more than one message at the same time.

Reverse Curve.—One whose curvature is first in one direction and then in the opposite direction.

Reverse Induced Current.—An instantaneous secondary current which opposes the primary current the moment a circuit is closed.

Reverser.—In telegraphy, a key for sending signals by reversing the current. This is done by shifting the line and the ground wire simultaneously from one pole of a battery to the opposite pole; a term sometimes used for *pole changer.*

Reversibility of Dynamo.—The ability of a dynamo to run as a motor, and supply mechanical energy when furnished with current from an outside source.

Reversible Bridge.—A form of Wheatstone's bridge which permits of a reversal of the proportionate arms for purposes of testing the resistance of the coils.

Reversible Heat.—The heat exhibited in the Peltier effect at the junction of dissimilar metals.

Reversible Heating Effect.—The so-called Peltier effect, in which if an electric current flows across the junction of two metals heat is either absorbed or given off according to the direction of the current flow.

Reversible Motor.—1. An electric motor so adjusted that its direction of rotation may be reversed, as in electric traction.

2. A motor designed to act as a dynamo when reversed.

Reversible Regenerative Armature.—A form of armature that generates an electromotive force when rotating in a reverse direction.

Reversing.—Changing a motion in one direction to a motion in exactly the opposite direction.

Reversing Cell.—A form of primary cell so constructed that, when placed on one end, the couple is separated from the electrolyte, and when reversed and set upon the other, the contact is effected and activity begins.

Reversing Controller.—An electric street car controller provided with a switch for reversing the motor.

Reversing Cylinder.—In an electric street car controller, a cylinder operated by a small reversing handle, and provided with contacts for reversing the connections of the field coils of the motors so that they will run in the opposite direction.

Reversing Gear.—A reversing cylinder, or any other means of reversing the direction of rotation in an electric motor.

Reversing Handle.—In an electric car controller the small handle which controls the reversing cylinder.

Reversing Key.—1. In quadruplex telegraphy, a form of double key for reversing the direction of the current.
2. A tapper for regulating the direction of the currents passing through a galvanometer.

Reversing Switch.—1. In telegraphy, a switch placed in the field magnet circuit of a dynamo for changing the direction of the current.
2. Any switch for reversing the direction of an electric current.

Reversing Wheel.—In a steam engine, the large hand wheel of a reversing gear.

Revetment.—Masonry walls placed up and down stream each side of a bridge, to protect the river banks from scour or erosion.

Revoke.—To annul by recalling or taking back; to cancel; to reverse.

Revolution.—A motion in a closed curve around a center, or a complete circuit made by a body in such a course.

Revolving Derrick.—An apparatus for both hoisting and swinging great weights; sometimes operated by electricity. It consists of a vertical mast supported by guys, and a boom hinged at the lower end for carrying the load. At the bottom of the mast is a bull ring or large wheel which receives the ropes used to revolve the derrick.

Rheostat.—A variable resistance box; a box containing spools of German silver or other alloy of low conductivity and small temperature coefficient, which are fastened to the under side of the cover. The wires terminate in brass blocks which may be electrically connected by plugs, which fit in holes between them, the resistance of the box being varied by the insertion or removal of the plugs. Carbon resistances are also used, and for very high resistances, liquid rheostats are necessary.

Rheostat Arm.—In a Wheatstone's bridge, the third arm of known resistance other than the two proportionate or *ratio arms.*

Rheostatic Controller.—In electric traction, a type of hand controller designed to control one or more motors by means of resistance only. They are not equipped for series parallel connection and therefore have a limited application. Also known as *type "R" controller.*

Rheostat Handle.—The controlling handle which governs the main cylinder of a car controller.

Rheostat Machine.—A machine for producing static effects, in which several condensers are charged in parallel and then discharged in series.

Rheostat Panel.—A switchboard panel containing connections with rheostat circuits.

Rheotometer.—A form of combination rheostat and Wheatstone bridge.

Rheotrope.—A name given to a pole changer, or to the commutator of an induction coil.

Rhigoline.—An extremely volatile fluid obtained in the distillation of petroleum, sometimes used in the process of flashing incandescent lamp filaments.

Rhodium.—A rare metal resembling palladium, found in platinum ores. It is silver gray and only fuses in the oxyhydrogen blowpipe, being also insoluble in acids when in the mass. It is sometimes used in an alloy for tipping pen points, but chiefly with platinum, in making the thermo couple of the Le Chatelier pyrometer.

Rhumbs.—The points of a mariner's compass, usually the four cardinal points N., S., E., W., and the four points intermediate between them NE., SE., SW., NW. The term is sometimes broadly used for all of the 32 points.

Ribbed Armature.—A slotted armature having projections along its length, leaving grooves between them for laying on the coils; *a projection armature.*

Ribbon Coil.—A coil having windings of insulated metal ribbons laid on flat, in place of wires.

Ribbon Conductor.—An electric conductor in the form of a metal strip or ribbon.

Ribbon Copper.—A copper conductor in the form of a ribbon or strip.

Ribbon Core.—A laminated ring armature core built up of iron strips or ribbons; a tangentially laminated core.

Ribbon Fuse.—A fuse consisting of a flat metal strip.

Ribbon Vibrator.—A make and break mechanism in which a strip of steel is caused to vibrate between the attractions of a spring and an electromagnet.

Right Angle.—That which is formed by one line meeting another so as to make equal angles with each other. The lines forming a right angle are perpendicular to each other.

Right Angled Trolley Crossing.—An insulated appliance fitted to a trolley wire at a point where two lines cross at right angles.

Right Handed Armature Winding.—An armature winding in which the coils are laid on in a direction corresponding to the movement of the hands of a clock as one looks at its face.

Right Handed Dynamo.—A dynamo whose armature turns with a right handed or clockwise rotation as viewed from the pulley end.

Right Handed Helix or Spiral.—A solenoid or coil of wire wound spirally about a core so that from which ever end the electric current enters, it will travel around in the same direction as the hands of a clock, the entering end becoming a south pole and the opposite end a north pole.

Right Handed Motor.—A motor whose armature turns with a right handed or clockwise rotation as viewed from the pulley end.

Right Handed Rotation.—A clockwise rotation. The movement of a rotating body from left to right following the direction of the hands of a clock when one is looking at its face.

Right Handed Screw.—A spiral screw whose threads are so cut that, in entering a nut, the latter must be turned *right handed.*

Right Handed Solenoid.—A spiral or coil in which the turns follow a right handed or clockwise direction; *a right handed helix.*

Right Handed Winding.—A winding in which the turns of the coils follow a clockwise direction.

Right Hand Engine.—In steam engineering, a horizontal engine whose fly wheel stands to the right when viewed from the cylinder.

Right Hand Trolley Frog.—A trolley frog designed to lead a trolley to a branch at the right of the main line.

Rigidity.—Want of pliability; the quality of resisting change of form, opposed to flexibility, ductility, malleability and softness.

Rim.—The border, edge, or margin of a thing; as, the rim of a wheel, usually applied to things which are circular or curving.

Ring Armature.—An armature, like the Gramme armature, whose coils are wound upon a core in the form of an iron ring.

Ring Clutch.—A ring shaped clutch for holding the carbon rod of an arc lamp, and feeding downward to maintain the arc.

Ring Connected Armature.—In a polyphase system, a dynamo armature connected into the system by the ring connection.

Ring Connection.—In an interlinked polyphase system of alternating currents, a method of connecting apparatus into the system by joining the circuits of the machine together in closed circuit, and connecting the points of connection of adjacent circuits to the lines of the system; in a three phase system this is known as the *delta* (△) *connection.*

Ring Core.—An armature core in the shape of a ring.

Ring Current.—In a three phase system, the current flowing between adjacent conductors.

Ringer.—The telephone calling apparatus, consisting of a magneto generator and a call bell operated by it; a *magneto call bell.*

Ringer Coils.—The windings in a telephone ringer, or magneto call bell.

Ringer Magnet.—A permanent magnet for operating a magneto call bell, or telephone ringer.

Ringing Key.—A key or switch by which a telephone operator sends a calling current to ring a subscriber's bell.

Ring Magnet.—A magnetized iron ring.

Ring Main.—In a system of electrical distribution, a main in the form of a ring.

Ring Off Drop.—In a telephone switchboard, a drop which falls when a subscriber "rings off" by hanging up his receiver.

Ring Off Signal.—A signal given at the switchboard of a telephone station when a subscriber hangs up his receiver at the end of his conversation.

Ring Oiling.—A method of shaft lubrication often employed with electric machinery. Rings of much greater diameter than the shaft are hung upon it with their lower portions dipping into a bath of oil. As the shaft rotates the rings travel around it carrying oil to the upper surface from the oil supply into which they dip.

Ring Potential.—In a three phase system, the effective potential difference between adjacent conductors.

Rings, Electric.—Nobili's rings or metallochromes. A phenomenon which may be observed when a solution of lead is subjected to electrolysis. If the anode be a plate of polished metal placed horizontally in the liquid beneath a platinum wire as a cathode, a deposit occurs of symmetrical rings of varying thickness exhibiting the colors of the rainbow.

Ring Spanner.—A wrench or key which completely encircles the nut, thus giving a perfect grip and obviating marks on finished work.

Ring Up.—To call up a subscriber from a telephone exchange to answer a call from another subscriber.

Ring Winding.—A method of armature winding. The winding is continuous, every second turn being connected to a commutator bar, making two turns per coil. This method is not much used except in certain generators for high voltage or large current. In ring winding it is customary to stencil upon the end faces a number of radial lines corresponding in breadth to the separate sections, so as to guide the winder in his work.

The separate sections of the coil are wound almost invariably on the cores separately, leaving the ends projecting, secured temporarily with string, and these ends are subsequently connected together and to the commutator. An inexperienced workman may easily connect up wrongly; making a left-handed winding instead of a right-handed one, or vice versa.

Rip Rap.—In civil engineering, broken stones for making foundations or walls, especially for throwing into deep water to form a bed for further work; also, a foundation of stones thrown loosely together.

Rise of Temperature in Dynamo Armature.—Whenever a mass of metal is rapidly rotated in a magnetic field, its temperature rises, the heat being the direct result of currents of electricity which are induced in the metal and known as Foucault or eddy currents. Their initial direction is at right angles to the lines of force of the magnetic field, and also at right angles to the direction in which the mass moves. It is possible to melt a piece of a metal which fuses at a low temperature by simply spinning it rapidly in a very strong field.

Risers.—1. In indoor wiring, conductors rising vertically from one floor to another; *vertical mains.*

2. In a water tube boiler, the *up flow pipes.*

Ritchie Photometer.—A form of photometer in which the lights are fixed at the ends of a bar, and the illuminations of the screen are viewed at right angles to the line of the lights, the screen, instead of the lights, being moved to equalize the illuminations.

River Cable.—A form of electric cable suitable for running across a river bottom; a *subfluvial cable.*

Riveted Rail Bond.—A rail bond formed of a length of wire or cable with copper terminals which are riveted into the rails, across the joints.

Riveted Rail Joint.—In electric traction, a joint between the ends of two rails formed by riveting steel fish plates from rail to rail.

Roaring Arc.—A voltaic arc which gives off a roaring sound when the carbons are too near together; a *noisy arc.*

Rock.—In geology, any natural deposit forming a part of the earth's crust, whether consolidated or not, including sand, earth, clay, etc., when in natural beds; a large fixed stone or crag.

Rocker Arm.—1. A stud mounted in a ring in such a way as to be adjusted or rocked back and forth in order to fit a

brush to its sparkless position upon a commutator; a *brush rocker.*

2. In a steam engine, a lever vibrating about an axis, as in various types of valve gearing.

Rock Faced.—A term applied to masonry where the center part of the face of each block is left rough, either as it came from the quarry, or else simply dressed with a spalling hammer. The outer portion is dressed smooth with a *drafted margin* from one to two inches wide according to the size of the stone.

Rocking Switch.—A switch which changes contacts by movement about an axis; a *throw over switch.*

Rod Clamp.—A clamp for securing the upper carbon of an arc lamp in its carbon rod.

Rod Clutch.—A clutch for gripping the carbon rod of an arc lamp, and controlling its downward movement in feeding forward the positive carbon.

Rodding.—In underground cable construction, a method of drawing a cable into a conduit; it consists in joining a number of rods end to end and pushing them into the duct one after another until the first appears at the next manhole, when a rope drawing the cable is attached to the last rod inserted, and the whole is pulled through.

Rod Switch.—A switch operated by pushing a rod.

Roebling Gauge.—A wire gauge used almost universally in the United States for iron and steel wire. Also known as Washburn and Moen's wire gauge.

Roentgengram or Roentgengraph.—A name sometimes given to an image of some object taken by means of Roentgen or X-rays upon a photographic plate; usually called *radiograph.*

Roentgen Rays.—A peculiar form of radiation usually known as *X-rays,* discovered by Prof. Roentgen in 1895. In experimenting with Crookes tubes he found that if the cathode rays from the negative terminal were focused upon a platinum reflector, a type of invisible radiation resulted, having remarkable properties. These rays have great penetrating power, passing freely through aluminum, zinc, wood, paper and flesh, but being stopped by platinum, lead, bone, etc. They affect photographic plates and excite phosphorescence in certain substances, strongly ionizing the air through which they pass. By means of these rays, in connection with a photographic plate, shadow-like pictures may be taken of the interior of opaque bodies. On this account, Roentgen rays are employed in medicine and surgery to locate foreign bodies and determine unusual conditions in the human body.

Roentgen Tube.—An X-ray tube. A form of Crookes tube developed by Roentgen in 1895 in his experiments with cathode rays. It consists of an exhausted glass chamber fitted with electrodes so that the cathode rays from the negative terminal are focused upon a platinum reflector, from which a still more penetrating kind of radiation emanates, known as Roentgen or X-rays.

Roentgen, Wilhelm Konrad.—Born 1845. A German physicist and experimenter. While professor of physics in the University of Würtzburg in Bavaria, he began in 1895 investigations of the cathode rays of a Crookes tube, resulting in the discovery of a new and remarkable form of radiation now known as Roentgen or X-rays.

Roentgram or Roentgraph.—A name sometimes given to a radiograph, an image of some object produced on a photographic plate by means of the Roentgen or X-rays.

Roget's Spiral.—An experiment to show the attraction of parallel currents; a spiral of copper wire is hung from a binding screw so that its lower end just tips in a mercury cup. When a current is passed through the circuit thus formed, the coils of the spiral attract one another and contract, raising the tip from the mercury surface and breaking the circuit; the circuit being broken, the coils relax, the circuit is again completed through the mercury, and the performance repeated.

Rolled Iron.—Iron or steel bars or sheets that have been brought to uniform dimensions by being passed through a rolling mill. Steel rails are produced by rolling.

Rolled Shafting.—Shafting which is finished to size between special rolls, thus avoiding the necessity of turning it.

Roller Bearing.—A bearing in which the journal rests upon and is surrounded by hardened steel rollers which revolve in a race surrounding the shaft. Friction is reduced by its taking place on a line, where the shaft and the roller touch each other, instead of over a surface, as with an ordinary brass.

Roller Chain.—A form of chain used in power transmission. It consists of a series of pairs of rollers, known as center blocks, similarly joined by side links. Each roller rotates loosely on a hollow core, which is turned to smaller diameter at either end to fit a perforated side piece joining the rollers into pairs. The side links are set over these side pieces and bolted in place through the cores.

In operation, a block chain with generous slack is liable to meet the sprocket with a clapping that at high speed becomes a continuous rattle. The roller chain largely avoids this trouble. Furthermore, being obviously easier in operation, it economises power. Some authorities estimate its efficiency in driving as high as ninety eight per cent. under favorable conditions.

Rolling Circle.—In drawing and designing wheel teeth, the circular pitch line upon which the *generating circle* is assumed to roll.

Rolling Contact.—Contact between a rotating body and the smooth surface which supports or embraces it, as with a wheel revolving on a rail.

Rolling Resistance.—The frictional load imposed by pressure upon or between a revolving body and a smooth surface; as, between a shaft and its bearing, when there is no relative movement of the parts in contact. The friction is much less than *sliding friction*.

Roman Cement.—A natural hydraulic cement, obtained by calcining and grinding *septaria* or nodules found in the chalk in various places. It has considerably less strength than Portland cement, but has the advantage of setting very quickly.

Roof Bracket or Standard.—In overhead wiring, a form of bracket provided with insulators for carrying wires over a roof.

Roof Truss.—A set of tension and compression pieces, so arranged as to support the weight of the roof.

Room Call.—An electric signaling system by which calls may be sent from the room of a hotel to the office for any service required.

Rope.—A construction of twisted fiber, as of iron, steel, manila and hemp, so intertwined as to form a thick cord capable of sustaining a severe strain. The distinction between a cord and a rope, other than wire, is made at one inch circumference, although in common speech, smaller sizes are often called rope. Ropes are ranked by seamen, under two descriptions, cable laid and hawser laid; the former composed of nine strands, or three great strands, each consisting of three small ones; the latter made with three strands, each composed of a certain number of rope yarns.

Rope Blocks.—Lifting tackle in which a running rope is employed; except for very heavy weights rope blocks are far handier for erecting and repairing work than chain blocks, whether differential or geared.

Rope Crane.—A traveling crane driven by an endless rope of cotton or hemp. The source of power may be attached to, or be at a distance from the crane. The cord travels at a very high speed, so that a minimum of power is required to lift a heavy load. The tension of the cord is maintained, and its slack taken up by tightening pulleys having their bearings in sliding frames, which are counterbalanced by suspended balance weights.

Rope Drive.—The transmission of power by means of rope gearing, the ropes being of either hemp or cotton, varying in diameter from ¾″ to 2″. The speed of ropes is from 3000 to 7000 feet per minute, 4500 being the average. The pulleys are usually of cast iron, the grooves on their surfaces being from 37° to 45°, the latter being the most common angle. Joints are made by splicing, the splice being 15 diameters in length, while the pulley should not be less than 30 times the diameter of the rope. Two plans are in use, one with independent ropes, suitable for transmitting power from an engine to numerous lines of shafting; the other, where only one rope is used, passing around all the grooves in turn and being kept taut by a tightener or jockey pulley, this last is very useful for drives at awkward angles or supplying power in series to a number of small units. With either plan the lower side should always be the driving side, and with the independent rope drive, a good horizontal sag should be given.

Rope Guard.—A rope arranged as a protection along dangerous passages.

Rope Transmission.—Driving machinery by power transmitted by cables or ropes.

Ropeway.—A line of wire ropes, suspended in air from derricks or pillars, upon which articles may be transported in buckets or slings depending from the rope, the carriers being usually hauled back and forth by smaller ropes wound in or out by windlasses. Much used in mining and other operations for transport over rough or uneven country.

Rosette.—In electric wiring, a device containing the terminals and fuses from which

a pendant lamp is suspended from a ceiling; a *ceiling cut out.*

Rotary.—1. Turning as a wheel upon its axle, as opposed to linear or reciprocal.

2. So constructed as to rotate on or around a shaft or axis.

Rotary Converter.—A dynamo for generating both direct and alternating currents; if conductors be led from the armature of a direct current machine to collector rings, alternating currents may be obtained; if the machine be run as a direct current motor alternating currents may be had at the collector rings; and if run as a synchronous alternating current motor, direct current may be obtained from the commutator; a *rotary transformer.*

Rotary Converter Substation.—In an electric traction system employing alternating currents, a sub-station to reduce high potential alternating current to low potential alternating current, and then to convert it into direct current at proper potential to feed into the trolley line.

Rotary Currents.—Polyphase currents combined so as to produce a rotary magnetic field; *rotatory currents*; *drehstrom.*

Rotary · Electrotype.—In printing, a form of electrotype with an arched or convex surface for fitting into the cylindrical surface of a rotary press.

Rotary Field.—An electromagnetic field produced by a combination of alternating currents differing in phase, such that a suitably wound armature if placed in the field will rotate because of induced currents. The action of the induction motor depends upon the creation of a rotary field.

Rotary Field Motor.—A term sometimes applied to the induction motor which is operated by a rotary magnetic field created by the stator that induces currents in the rotor conductors.

Rotary Magnetism.—The magnetism existing in a rotary magnetic field.

Rotary Phase Converter.—A machine for converting from an alternating current system of one or more phases to an alternating current system of a different number of phases, but of the same frequency.

Rotary Pump.—One which has a circular motion; a pump whose piston or pistons partake of the nature of cams, rotating upon an axis and being in contact at one or more points with the walls of the enclosing chamber. A rotary pump differs from a centrifugal in that the latter, by means of a fan or impeller, imparts velocity to a stream of fluid, while the rotary pump continuously scoops the fluid from out its chamber.

Rotary or Rotating Currents.—Alternating currents displaced in phase relative to each other so as to produce a rotary magnetic field, as when two alternating currents are displaced in phase by 90 degrees or three currents by 120 degrees. Induction motors operate by rotary currents.

Rotary Valve.—A valve in which the disc, plug or other device, used to close the passage, is made to rotate back and forth for opening or closing; as, the Corliss valve.

Rotating Brushes.—Metal discs sometimes caused to rotate about the commutator of a dynamo armature to draw off the current, in place of the usual commutator brushes.

Rotation.—The act of turning upon an axis or center; as, a wheel upon its axis.

Rotator.—In photometry, a device operated by an electric motor for rotating an incandescent lamp about a vertical axis in order to obtain the mean horizontal candle power, as the light given by the lamp varies in different planes.

Rotometer.—In submarine cable operations, an instrument attached to a cable laying drum or sheave to measure the length of the cable as it passes over the drum.

Rotor.—1. In a dynamo, or other machine, the part which rotates.

2. In an induction motor, the rotating part, which is usually the armature, as distinguished from the *stator* or fixed part.

3. In a steam turbine, a part of a machine which revolves as compared with that which remains stationary, or the *stator.* The term was originally applied to the revolving part of an alternating or polyphase generator, as in some dynamos the field magnets are revolved, while with others, the armature is the moving portion, and a general designation was necessary. Since the advent of the steam turbine, the same appellation has been given to the drum or wheel, furnished with blades, which is driven by the steam.

Rotor Armature.—A rotating armature.

Rotor Coils.—The winding of a rotor armature.

Rotor Currents.—Currents produced by a rotating armature.

Rotor Field.—The electromagnetic field generated by a rotating armature.

Rotor Slots.—Openings punched in the circumference of the rotor, or rotating part of an induction motor, for the reception of the windings. The number of slots in the rotor per pole per phase must be prime to that of the stator in order to avoid dead points at starting, and to insure smooth running.

Rotten Stone.—A name given to the residuum of naturally decomposed impure limestone, and also sometimes applied to a sort of infusorial earth known as "tripoli." It is sometimes employed in packings and in insulation compounds.

Rough Dimension.—In mechanics, it is necessary to give certain allowances of extra thickness of metal in all work which has to be machined, whether castings or forgings, so that they are larger by this amount than the finished dimensions. These are called the rough dimensions, and in the pieces of work, whether rough castings or rough forgings, so long as sufficient thickness is allowed for machining, very close accuracy is not looked for, nor is it necessary.

Round Wire Gauge.—A form of wire gauge, such as the American and Birmingham wire gauges, consisting of a circular metal disc with graduated notches cut around the circumference.

R. P. M.—Abbreviation for *revolutions per minute.*

R. P. S.—Abbreviation for *revolutions per second.*

R. Q.—A signal used in submarine telegraphy to ask for the repetition of any doubtful portion of a message.

Rubber.—As applied to insulation, rubber is used in many ways. In the form of a thin plastic mass it may be laid over a wire and then vulcanized. It may be used as tape for direct insulation or for making joints. As vulcanite or ebonite it may be used as plates, tubes, rods, switch handles, etc.

Rubber Covered Wire.—A conductor for interior wiring consisting of a tinned copper wire with a rubber covering, protected by an outside braiding of cotton saturated with a preservative compound.

Rubber Insulator.—A form of line wire insulator made of india rubber, and containing an iron hook, often used on the under side of cross arms, especially on roof fixtures.

Rubber of Electric Machine.—In a frictional machine, a cushion of leather which presses against the rotating disc or cylinder.

Rubber Solution.—India rubber or caoutchouc dissolved in benzine or bisulphide of carbon, forming a cement for securing insulating tape, etc., on electrical apparatus.

Rubber Substitute.—Any manufactured compound designed to take the place of india rubber by providing similar properties at less cost of production. They are sometimes used to mix with pure rubber for reducing the cost without injuring the efficiency.

Rubber Tape.—A specially prepared insulating, adhesive tape impregnated or coated with india rubber.

Rubbing Contact Key.—A key which makes an electrical contact by rubbing between contact parts.

Rubble.—Water worn or rough stones, broken bricks, etc., used in coarse masonry, or to fill up between walls; thin or irregular stones built up without regard to courses.

Rubble Arch.—An arch composed of irregular or broken stone or fragments of stone mingled with cement or clay; when building an arch of rubble stones, care should be taken that they are long and narrow, and roughly dressed to a wedge shape. They should be set in cement mortar, as their stability largely depends upon the mortar.

Ruhmkorff, Heinrich Daniel.—Born 1803, died 1877. A German electrician; inventor (1851) of the induction coil which bears his name.

Ruhmkorff's Coil.—A form of induction coil perfected by Ruhmkorff: it consists of two insulated coils: one, the *primary,* having few turns of comparatively coarse wire, and the other, the *secondary,* with many turns of fine wire, wound upon a hollow cylinder enclosing a core of soft iron wires; the primary is joined to a battery, and includes an interrupter and commutator.

The number of magnetic lines created and destroyed at each *make* and *break* is the same, but

by the use of a condenser, the current at make is caused to take a considerable fraction of time to grow, while at break the cessation is instantaneous. The rate of cutting of the magnetic lines is therefore much greater at break than at make. The effect of the condenser is to suppress the counter current at make and to increase the direct electromotive force at break. The sparks are longer, and pass only one way. The condenser does this by the action known as electric *resonance.*

Ruhmkorff's Commutator.—A current reverser designed to reverse the direction of the battery current sent through the primary of a Ruhmkorff's coil.

Rumble.—A rotating cask or box in which small articles are polished, preparatory to electroplating, by the friction against one another as the rumble turns.

Rumford's Photometer.—The shadow photometer devised by Rumford. It consists of a ground glass screen in front of which is fixed an opaque rod, shadows of which are thrown on the screen by the two lights to be compared. When the lights are adjusted so that the intensities of their shadows are the same, the intensities of the lights are proportional to the square of their distances from the screen.

Run Down Cell.—A cell that has become inactive through polarization or exhaustion.

Running an Engine.—The act or art of attendance upon a prime mover, maintaining it in a proper condition for safe and economical running, seeing that all parts are properly lubricated while in motion, and making such repairs and adjustments as are necessary for its best efficiency. By extension, the care of the engine includes care for the boiler or other means of producing the working fluid, the greatest responsibility of an attendant being to maintain a proper water level in the boiler. The processes of keeping internal surfaces free from scale, heating surfaces clean from soot, together with the adoption of economical methods of firing, prompt repair of small leaks, avoidance of corrosion, straining by rapid steam raising, and waste of steam by blowing off, all mark the careful engineer of a steam plant.

Running Board.—In pole line construction, a device sometimes employed for heavy work; it consists of a board to which the wires are fastened and which is drawn by horses away from the reels from pole to pole, the wires being passed over the cross arms and fastened to the insulators by linemen stationed upon each pole.

Running Fit.—That fit in practical mechanics where one part will run in another when lubricated, the amount of difference between the male and the female part depending upon the class of the work. Thus, for a 2 inch shaft, the hole would be bored from .0015 to .0035 inch larger, the latter size giving a very easy fit.

Running Over.—In steam engineering, an engine is said to *run over* when the valve is so set that the top of the fly wheel rim runs away from the cylinder.

Running Position of Controller.—The position of the handle of a car controller when the car is in motion.

Running Torque of Motor.—The torque developed by a motor in running.

Running Under.—In steam engineering, an engine is said to *run under* when the valve is so set that the bottom of the fly wheel rim runs away from the cylinder.

Runway.—1. The channel or bed of a stream.

2. The elevated tracks for traveling cranes, hoists, and parcel carriers.

Russia Iron.—A special kind of sheet iron manufactured in Russia and used for lagging engines, boilers, etc. It is made by a secret process, which produces an iron that has a very hard and highly polished surface, thus rendering it easy to keep clean. A similar material is produced elsewhere under the name of *planished iron.*

Rust.—The reddish or brownish yellow coating on iron exposed to moist air; an oxide of iron which forms a rough coat on its surface.

Rust Joint.—A joint employed by engineers where it is necessary to withstand high water pressure, the joint being filled with a paste which oxidizes the iron, the whole rusting together and hardening into a solid mass. A good recipe is 80 lbs. cast iron borings or filings, 1 lb. sal ammoniac, 2 lbs. flowers of sulphur, mixed to a paste with water.

S.—1. Symbol for area of cross section.

2. Abbreviation for the *south seeking* pole of a magnet.

s.—Abbreviation for *second*, the unit of time.

Saddle Bracket.—A bracket erected upon the top of a telegraph pole for supporting the insulator for the saddle wire.

Saddle Wire.—A line wire carried by a saddle bracket upon the top of a telegraph pole.

Safe Alarm.—An electric burglar alarm attached to the door of a safe.

Safe Carrying Capacity.—The maximum current strength that a conductor can safely carry without dangerous heating.

Safe Internal Pressure.—The safe internal pressure on cylindrical shells is found according to the following rule, which has been adopted by the United States Board of Supervising Inspectors, and any boiler shell can be determined by this rule: Multiply one sixth of the lowest tensile strength found stamped on any plate in the cylindrical shell by the thickness expressed in inches or parts of an inch of the thinnest plate in the same cylindrical shell, and divide by the radius of half diameter, also expressed in inches, and the result will be the pressure allowable per square inch of surface for single riveting, to which add twenty per cent for double riveting.

Safe Load.—The amount of loading or of force which may be borne without risk by a structure, or by any one of its members. Not only should the safe load be but a fraction of the ultimate strength of the piece, but it should also lie well within the elastic limit of the material.

Safety Arch.—In building, an arch formed in the body of a wall, as over a door or window, to distribute and relieve the pressure.

Safety Device.—A device carrying a piece of fusible metal which melts with a current of given strength, or a device actuated by an electromagnet, for opening a circuit when the electric current exceeds a definite limit.

Safety Device for Multiple Circuit.—A safety fuse for cutting a branch circuit or receptive device out of a multiple circuit system when the current becomes excessive.

Safety Factor.—1. The ratio between the maximum electric pressure which a transformer is designed to sustain, and the normal pressure which it is expected to carry during operation.

2. The number of times the ultimate or breaking strength of the material or structure is designed to exceed the strains to which anything is put in ordinary circumstances. The safety factor varies greatly, depending on the nature of the load and the material used in construction. Also called *factor of safety.*

Safety Fuse.—A device, usually consisting of a wire or strip of a fusible conducting metal, such as an alloy of tin, introduced into a circuit for the purpose of protecting apparatus and buildings from damage by an unduly strong current, the fuse melting and opening the circuit the moment the current strength exceeds a definite limit; also called *safety cut out.*

Safety Fuse Block.—A block of porcelain or other insulating material upon which one or more safety fuses are mounted.

Safety Lamp.—An incandescent lamp specially designed for use in mines and similar places where there is danger of fire damp or other explosive conditions.

Safety Link.—A link fuse for use on low voltage circuits, consisting of a link or strip of fusible material which melts and opens the circuit when the current becomes too strong.

Safety Plug.—1. A plug provided with a safety electrical fuse so that, when inserted in a socket, the circuit is completed and protected by the fuse.

2. A hollow plug, filled with a lead tin alloy, which melts at a point slightly above the temperature of the steam in a boiler. Such plugs are screwed into various places; such as the fire box crown or the roof of the combustion chamber, and are designed to melt if the water

runs low, thus putting out the fire and preventing over heating of the plates. Also known as *fusible plug.*

Safety Valve.—A circular valve seated on the top of a steam boiler, and weighted to such an extent, that when the pressure of the steam exceeds a certain point, the valve is lifted from its seating and allows the steam to escape. Safety valves may be loaded directly with weights, or the load may be transmitted to the valve by a lever. Again, the end of the lever is sometimes held down by a spring, or the spring may be applied directly to the valve seat.

Sag.—The extent to which a wire dips by its own weight at the middle of the span between two points of support.

Sag Error.—In pole line construction, an error in computation arising from failure to allow adequately for sag in the wires.

Sag of Belt.—In the location of shafts that are to be connected with each other by belts, as between an engine and a dynamo, care should be taken to secure a proper distance, one from the other. This distance should be such as to allow of a gentle sag to the belt when in motion. A general rule may be stated thus: Where narrow belts are to be run over small pulleys, 15 feet is a good average, the belt having a sag of 1½ to 2 inches. For larger belts working on large pulleys, the distance should be 25 to 30 feet, the belts working well with a sag of 4 to 5 inches.

Saint Elmo's Fire.—A name given by sailors to a form of glow electric discharge sometimes appearing under certain weather conditions at sea as a pale blue flame at the tops of the masts or the tips of the spars; the *corposant.*

Sal Ammoniac.—Ammonium chloride. A substance chiefly obtained by distillation of the ammoniacal liquor of gas works, neutralization with hydrochloric acid, and concentration of the liquid by evaporation until crystals are formed. The chloride is very soluble in water, and is used to a great extent as the electrolyte in open circuit primary cells. In electroplating it serves as a conducting salt for many baths.

Salient Poles.—The poles of a dynamo or motor field magnet occurring at the ends of the pole pieces, as distinguished from *consequent poles.*

Salinometer.—A glass or metal instrument by which the density of salt water is ascertained. It consists of a weighted bulb, to which is attached a graduated stem, and its action is to indicate the amount of salt held in solution in the water, by floating higher or lower; higher for density, lower for freshness. Some are graduated into 33rds and some into 32nds, each representing about five ounces of salt to a gallon of water.

Salt.—1. In chemistry, the neutral compound formed by the union of an acid and a base; thus, sulphuric acid and iron form the salt of sulphate of iron or *green vitriol.*

2. The chloride of sodium, a substance used for seasoning food, for the preservation of meat, fish, etc. It is found native in the earth, and is also produced by evaporation and crystallisation from sea water and other water impregnated with saline particles.

Salted Carbon.—An arc lamp carbon impregnated with metallic salts such as calcium or magnesium, for use in the flaming arc lamp.

Sand Barrel Setting.—In pole line construction in loose or sandy soil, a barrel filled with earth used as a base into which the butt of the pole is set.

Sand Bending.—The process of bending lead or other pipes after having first filled them with sand and plugged the ends.

Sand Box.—In electric traction, a box of sand carried by a car for the purpose of sprinkling it along the track in order to prevent slipping of the wheels.

Sandstone.—A rock made of sand, more or less firmly united. Siliceous sandstone consists mainly of quartz sand, but, if very hard, it is often called *grit.* Granitic sandstone consists of granitic sand; argillaceous sandstone contains much clay.

Sandy Deposit.—In electroplating, a deposit of a granular character which results when the electric current is too strong.

Sash Lines.—In pole line construction, ropes employed to raise telegraph poles of such size and weight as to require the use of a derrick.

Saturated Flux.—Lines of magnetic force sufficient to produce in a magnet a state of saturation.

Saturated Solution.—A liquid which holds in solution all that it can dissolve of a substance at a given temperature.

Saturation.—1. The degree of magnetic force which can be permanently imparted

to the core of a magnet; *magnetic saturation.*

2. In steam engineering, a vapor is said to be saturated when it has a *temperature due to its pressure.* It then holds a quantity of moisture in suspension and is not in the condition of a true gas. Also called *dry* steam and *saturated* steam.

The heat required to generate one pound of saturated steam from water at 32° F., is as follows:

		Heat Units
Sensible heat, to raise the water from 32° to 212°........................		180.9
Latent heat, 1, of the formation of steam at 212°=	894.0	
2, of expansion against the atmospheric pressure, 2116.4 lbs. per sq. ft.×26.36 cu. ft. =55,786 foot pounds ÷778=	71.7	965.7
Total heat above 32° F..........		1146.6

Saturation Factor.—A factor for fixing the degree of saturation in an electromagnetic circuit. It is the ratio of a certain per cent of increase in exciting ampere turns of a machine to the corresponding per cent increase in magnetic flux thereby produced.

Saturation of Coil.—In gas engine ignition, an interval of time is required to saturate the coil, make the break and discharge the core, producing the jump spark. The average duration of these operations is about .005 second, which, although quite negligible at low speeds, requires progressive advances of the time as speed increases. The movement of the vibrator also consumes a fraction of a second, its speed being indicated by the pitch of its buzz, but unless the speed be very high, the time for occurrence of the spark is changed. If the vibrator be leaving contact with the core at the moment of circuit-making in the commutator, the time of one vibration must elapse before the occurrence of the spark; if the vibrator be in contact at this moment, the spark follows almost immediately.

In a multiple-cylinder engine using a separate coil for each cylinder, unless the vibrators be tuned as nearly as possible to the same pitch or rate of vibration, the sparks will occur at different points of the several respective piston strokes.

Saw, Electric.—1. A platinum wire heated to incandescence by the electric current for the purpose of cutting certain substances.

2. A circular, or other saw run by electric power.

Saw Tooth Roof.—One whose sides are made unequal with slopes. The short, nearly vertical slope is glazed, and faces the point whence the most sunlight may be expected, the long flat slope is better calculated to withstand the pressure of snow or wind, and the light is not obscured by snow. Also called *weaving shed roof.*

S. C.—Abbreviation for *secondary current.*

Scaffolding.—A temporary structure of timber, boards, etc., for various purposes; as, for supporting workmen and materials in building, etc.

Scalar.—In physics, a quantity which has magnitude, or magnitude and sign only, without direction, such as density, mass, energy, etc., as distinguished from a *vector* quantity.

Scale Rule.—1. A graduated measurement wherein a large linear dimension is represented by a smaller. By this means, a structure or machine may be represented in a small drawing, each quarter inch of the drawing being equal to one foot of the structure, and so on. Such scales range from those of a map, where some hundreds of miles may go to one inch, up to those of engineering details, which are usually one-fourth to one-half the size of the original.

2. A rule graduated in accordance with the foregoing, whereby a draughtsman reads off feet, yards, miles, etc., without conversion.

Scapple.—To work roughly, or shape without finishing, as a stone before leaving the quarry. To dress in anyway short of fine tooling or rubbing, as stone.

Scarf Joint.—1. A form of lap joint for connecting the ends of two conductors, in which each wire is cut diagonally, the faces of the two cuts laid together so as to preserve uniform the dimensions of the wire, and the whole secured with solder.

2. In leather belting, a lap joint made by skiving the edges at the junction.

3. In carpentry, a joint made by overlapping and bolting or locking together the ends of two pieces of timber that are halved, notched or cut away, so that they will fit each other and form a lengthened beam of the same size at the junction as elsewhere.

Scavenging.—In internal combustion engines, the expulsion of burnt gases from the cylinder after explosion, the operation being sometimes assisted by a jet of fresh air. A scavenging effect is produced in four cycle engines, by means of a long exhaust pipe with easy bends, the momentum of the gases producing a partial vacuum in the cylinder. If the exhaust and admission valves be placed diametrically opposite each other, on the sides of the clearance space, the same effect may be produced, the process being aided by holding open the mechanically operated exhaust valve until the piston has begun its charging stroke.

Schisiophone.—An automatic hammer combined with an induction balance for detecting flaws and structural imperfections in iron rails and other metallic products.

Schist.—Any rock that readily splits or cleaves; slates and schists are essentially the same.

Sciagraph.—A name sometimes given to a *radiograph*, a photograph obtained by the use of the X-ray.

Sciagraphy.—A term sometimes used for *radiography*, the science of the use of X-rays.

Scientific Instruments.—The tools or apparatus wherewith analyses are made, researches conducted, or any form of experiment carried out. The appliances vary according to the need of the different professions; some, as the *microscope*, *thermometer*, *barometer*, and delicate *balances*, being common to all, while others again are highly specialized. The list covers everything from the huge telescope, requiring its own building and special machinery to drive it, down to the watchmakers' eyeglass, and from the testing machine which tries a whole ship's cable at one time to the pocket steel yard.

Scintillating Jar.—A Leyden jar which, instead of having a complete coating of tin foil, has bits of foil distributed upon it so as to leave short spaces between each piece, so that, when discharged, sparks appear at the intervals; *a luminous jar.*

Scintillation.—The emitting of light, as it were, in sparks or flashes; glittering in flashes as diamonds, etc., by artificial light.

Scissel.—The clippings of metals made in various mechanical operations.

Scobs.—The dross of metals; raspings of ivory, metals or other hard substances.

Scoop.—A fireman's shovel.

Scouring Paste Recipe.—The following composition is recommended for scouring woodwork or utensils, taking the place of soap or sand: 1 lb. of soft soap, 1 lb. silver sand, 1 lb. powdered whiting, 1 tablespoonful common salt; all put into a vessel containing 1 quart of boiling water; the whole to be boiled and well stirred for 15 minutes.

Scraped Joint.—A joint brought to an accurately plane surface by scraping. Irregularities of the surface are found by rubbing a film of *marking* (oil and red lead) on a surface plate, or on the already finished surface which is to fit that one being operated upon. On bringing the two surfaces into contact, patches or spots of the marking appear on the high places, and these are carefully removed by the scraper, the process being repeated as often as necessary.

Scraper.—A hand tool for removing a very small amount of metal from a surface; it is generally a file or piece of hard steel flattened, tapered, and ground square across at the end.

Scrap Heap.—A receptacle for odds and ends of waste material, capable of being utilized in various ways. Scrap cast iron consists, to a slight extent, of foundry wasters, but chiefly of old iron bought for the purpose of remelting, while the scrap heaps of wrought iron or steel consist of the accumulation of shop refuse and odds and ends cut to waste. Also called *scrap pile.*

Scratch Brush.—A brush composed of a bundle of stiff wires six or eight inches in length, bound together for the purpose of cleaning metallic objects preparatory to electroplating.

Scratch Brushing.—The process of cleaning metallic objects with a scratch brush preparatory to electroplating.

Screed.—In building, a wooden strip or a strip of mortar laid on a wall at intervals to gauge the thickness of the plastering to be put on, so that the finished work may present a uniform appearance.

Screen.—A large sieve of wide mesh, on which such materials as sand, gravel or coal are sifted.

Screen, Electric.—A screen of perforated tin foil or wire gauze used to protect delicate instruments from external electrostatic induction.

Screen, Magnetic.—When any substance is interposed between a magnetic needle and a magnetizing force the magnetism will act across the intervening substance just as if it did not exist, with the single exception that if the screen consists of iron or steel no outside magnetic force will penetrate it. This is because the iron being itself magnetic the lines of force seem to be absorbed by it without passing through it.

Screw.—In mechanics, an inclined plane wrapped around a cylinder. The distance apart of two consecutive coils, measured from center to center or from upper side to upper side (literally the height of the inclined plane) for one revolution, is "the pitch" of the screw.

Screw Bolt.—In machinery and construction work, more commonly called *machine bolt*; signifying, therefore, a fastening made by means of a nut engaging with a screw thread, as distinguished from the riveted form of fastening.

Screw Cleat.—In indoor wiring, a cleat carrying the necessary screws for quickly attaching it to the walls.

Screw Jack.—A device whereby a powerful force may be exerted through the continued application of a small force acting through a comparatively long period of time. The jack consists essentially of a vertical screw, working in a nut, within a substantial frame; rotation of the screw, by means of levers or toggles thrust through holes in its head, causes a multiplication of the power exerted, equal to the circumference of the path traveled by the force on the bar, divided by the pitch of the helix.

Screw Nail.—A common wood screw, as distinguished from an ordinary nail driven in by percussion, the term being akin to the term *screw bolt.*

Screw Pitch Gauge.—A small instrument furnished with a number of thread gauges, usually ranging from 28 to 6 per inch, for ascertaining the pitch or number of threads per inch of any given screw. The various gauges are mounted, like blades on a pocket knife.

Screw Threads.—There are many kinds of screw threads in general use among mechanics; the three more important are· (1) the V standard thread, having an angle of 60° between its sides, which is one of the standards for machine bolts; (2) the *Sellers* or *U. S. Standard* thread, with an angle of 60°, one eighth being flattened off at top and bottom of the thread; (3) the *Whitworth*, having an angle of 55°, one sixth of the depth of the thread being rounded off at top and bottom.

Screw Wrench.—A wrench for turning a screw; a wrench with an adjustable jaw that is moved by a screw.

Scriber.—A steel tool for marking lines on work. The scriber used by machinists is usually pointed at both ends, one end being turned at a right angle to mark or test surfaces; other patterns have a point at one end and a hook at the other. The scriber used for marking timber has a point at one end, for scratching, and a knife at the other for cutting, the marks. Also called *scriever.*

Seal.—A piece of lead used to seal up a *meter* in order to prevent tampering.

Sealing In.—The process of introducing an incandescent lamp filament, after being properly mounted, into the lamp chamber, and hermetically fusing the junction around the neck of the bulb.

Sealing Incandescent Lamps.—After the air has been sufficiently exhausted, the small tube connecting the bulb to the exhaust tube is fused, drawn out to a thread, and the lamp *sealed off*. The vacuum is usually tested by means of an induction coil, by fusing two platinum wires into the glass tube leading to the lamp, and connecting these wires to the secondary terminals of the coil. The distance between the ends of the wires inside the tube is so adjusted that when the required degree of vacuum is attained, a spark passes through the air outside the tube in preference to traversing the vacuous space between the platinum points.

Sealing Off.—The process of drawing to a thread the end of an incandescent lamp bulb from which the air has been exhausted, and fusing it off.

Sealing Wax Rod.—In rudimentary experiments for illustrating static electricity, a rod of sealing wax is rubbed with wool or flannel and held near suspended pith balls or loose bits of paper to show electrical attraction. Electricity so produced is called *resinous* electricity or *negative* electricity.

Sealing Wires.—Wires by means of which the lead seal is applied to a meter.

Searchlight.—A powerful electric lantern containing a focusing arc lamp between a system of reflectors and a lens, for projecting the light to a great distance; an *electric projector*.

Seat.—1. The bedding of anything upon its foundation or base, or the adjustment of one part with that other upon which it rests, so that it cannot rock or vibrate.

2. The portion or face of a building stone which rests upon the mortar bed.

3. The piece whereon a valve rests when closed, and from which it rises on opening; as, in a safety valve or stop valve.

Sea Telegraphy.—A term sometimes used for submarine telegraphy in which messages are sent along a cable laid on the bed of the ocean; also, rarely, for wireless telegraphy which is employed for communication between vessels at sea.

Secohm.—A term proposed for the practical unit of self-induction, now called the *henry*.

Second.—The unit of time in the C. G. S. system of measurement; it is equal to $\frac{1}{86400}$ of the mean solar day.

Secondary.—1. A term commonly used for a secondary coil.

2. In an induction motor, that part in which currents are induced by the field coils.

Secondary Admittance.—Admittance in the primary coil of a transformer, or in the secondary of an induction coil.

Secondary Ampere Turns.—The number of ampere turns in the secondary coil of a transformer or induction coil.

Secondary Battery.—One in which electrical energy may be stored. It consists essentially of a number of leaden plates, immersed in dilute sulphuric acid within a vessel of glass, vulcanite or other insulating material. The plates are made in the form of grids, their interstices being filled with a paste composed of lead oxides such as minium and litharge, the former for the positive plates, the latter in the negative. The action of the batteries is as follows: the sulphuric acid appears to attack the lead oxide and convert it into sulphate; on supplying the charging current the acidulated water decomposes, the hydrogen going to the *cathode* or negative plate and converting the lead sulphate into metallic lead, the oxygen converting that on the *anode*, or positive grid, to peroxide. This is shown by the blue color of one and the reddish brown of the other. When the chemical action is completed, the gases bubble up through the liquid, showing that the battery is charged. The elements are in a state of tension, and the work done by the battery is the attempt to restore the equilibrium. An accumulator will restore about 80 per cent of the power spent in charging it; the current discharge at about 2 1 volts for each cell being reduced to 1.8 volts as the cell is exhausted. A secondary battery is commonly known as a storage battery or accumulator.

Secondary Cell.—A cell forming a unit in a *secondary* or *storage battery*, as distinguished from a *primary cell.*

Secondary Circuits.—In gas engine ignition, in order to obtain a secondary current with the use of a chemical battery or direct current mechanical generator, it is necessary to interrupt the primary circuit at timed intervals. There are two methods by which this is accomplished: 1, by the use of a snap cam that once in every revolution brings together the terminals of the circuit, and 2, by the use of a timer and a magnetic vibrator at one pole of the coil core.

Secondary Clock.—In a system of electric time keeping, a subordinate clock whose movement is controlled by the primary, or master clock.

Secondary Coil.—1. In a transformer, a coil usually consisting of a few turns of heavy insulated copper wire in which the current at high pressure of the primary is induced, transformed, and given out as a large current at low pressure.

2. In an induction coil, the winding in which the currents are induced by the primary, the *secondary*, as distinguished from the *primary*.

Secondary Current.—1. The current induced in the secondary of a transformer or induction coil.

2. A current in the circuit of a secondary or storage battery.

Secondary Cut Out.—A safety fuse included in the circuit of the secondary coil of a transformer.

Secondary Electromotive Force.—The electromotive force or pressure in the secondary coil of a transformer.

Secondary Frequency.—The alternating current frequency induced in the secondary of an induction motor.

Secondary Generator.—A name sometimes given to a secondary or *storage cell.*

Secondary Impedance.—The impedance existing in a secondary circuit.

Secondary Main.—In electric lighting, the main coming from the secondary coil of a transformer or converter, which conveys current to the lamps.

Secondary Movers.—Machines, or mechanical parts, to which motion is conveyed from a prime mover.

Secondary of Induction Motor.—That part of an induction motor, usually the rotating part or rotor, in which currents are induced by the field coils.

Secondary Plate.—The disc or plate of a condenser in which a charge is produced by induction from the primary plate.

Secondary Resistance.—The resistance existing in the circuit of a secondary coil.

Secondary Source of Light.—A luminous source which reflects luminous energy received upon it, or diffuses luminous energy passing through it, as distinguished from a primary source.

Secretion Current.—In electro-therapeutics, an electric current produced by stimulating the secretory nerves.

Section.—1. In a multiple telephone switchboard, a division of the board containing spring jacks for every line entering the exchange, but line drops of those subscribers only whose calls are received at that particular section.

2. In a simple telephone switchboard, a name sometimes given to a panel of the board.

3. In electric traction, a trolley section, an insulated length of the trolley wire furnished with its own feeders.

Sectional Coils.—Windings applied to an electromagnet in separate sections.

Sectional Covering. — Non-conducting material, such as magnesia or asbestos, made into cylindrical or other segments to fit around steam pipes, etc., thus enabling the covering to be quickly removed for repairs or alterations, and as quickly replaced.

Sectional Feeder.—A feeder wire employed to supply current to a trolley section.

Sectional Plating.—A method of electroplating an article, in which a coating of special thickness is deposited at those points on the surface which are expected to have the greatest wear.

Sectional Plating Frame.—In electroplating, a frame for holding an article in the bath so that it shall receive a thicker deposit of metal at certain points than at others.

Sectional Trolley.—A trolley line made up of sections of wire fed by separate feeders from the power house and joined by *section insulators* or *line breakers*.

Section Box.—In a system of electric traction, a box containing the switches which control the sectional feeders.

Section Circuit Breaker.—A circuit breaker introduced into a trolley section for opening the circuit and cutting out a section of the line.

Section Insulator.—In a trolley system, an insulating device for clamping the terminals of two sections of the line, and permitting the trolley wheel to pass without any shock.

Section Switch.—In a trolley system, a switch by means of which a trolley section may be cut out of the line circuit when necessary.

Secular Variation.—A variation in the declination of the magnetic needle at the same place on the earth's surface which may be observed during long periods of time.

Seebeck Effect.—A thermo-electric effect discovered by Seebeck. He observed that an electric current was produced in a closed circuit by heating a point of contact of two dissimilar metals. The two metals producing this effect are known as a *thermo-electric couple*.

Seebeck, Thomas Johann.—Born 1770, died 1831. A German physicist, and experimenter in thermo-electricity. In 1822 he discovered the thermo-electric effect which is known by his name. He observed (1822) that a current was produced in a closed circuit by heating the point of contact of two dissimilar metals. This effect led to the development of the thermo-electric pile, in which metals were arranged in a series depending on their thermo-electric relations.

Seep.—To soak through pores; to lose liquid by drainage.

See Sawing.—A term applied to the state of two parallel connected alternators running out of step, or not synchronously: *hunting*.

Seger Cone.—A pyrometric device used to measure the heat of a furnace. The cones constitute a series of slender triangular fire clay pyramids, about 3" high by ⅝" broad at the base, each being slightly less fusible than the next. The temperature at which each becomes plastic is known, its "weeping" or bending over, until its apex touches the hearth on which it stands, indicating the degree of heat, which is read from the Seger scale.

Segment.—One of the parts into which a body naturally separates or is divided; a part cut off from a figure by a line or plane; especially, that part of a circle contained between a chord and an arc, or so much of a circle as is cut off by the chord.

Segmental Core Disc.—An armature core disc made up of several segments, instead of being in a single piece.

Segment Switch.—A form of switch in which contacts are made by a lever moved over insulated metallic segments in the form of an arc.

Seismic Photo-chronograph.—An instrument for making photographic record of disturbances of the earth's crust.

Seismograph.—An instrument for measuring and recording the period, extent and duration of earthquakes; *a seismometer.*

Seizing.—1. The lashing or securing of two ropes or two parts of a single rope by binding them around with smaller line or yarn.

2. The yarn or cord used in seizing a rope or ropes.

3. Binding or gripping of a moving part in its bearings, when the parts have become incorporated by overheating or lack of lubrication. Steel on steel is very apt to *seize*, and therefore, it is good practice to face bearings for steel shafts with some other metal, as brass.

Selective Absorption.—Absorption of sound, light, heat, etc., with a discrimination for waves of certain frequencies, other waves passing unabsorbed.

Selective Radiation.—Radiations from a body in waves of sound, light, heat or electromagnetism confined to certain definite frequencies only; also called *selective emission.*

Selective Resonance.—In alternating current circuits, a resonance obtained within limited frequencies.

Selective Transparency.—The quality of a body which absorbs light waves of certain frequencies, and transmits others of different frequencies.

Selector.—In automatic telephony, a switch provided for every subscriber connected with an exchange for the purpose of connecting the calling telephone with the proper *connector*, which, in turn, connects with the telephone of the subscriber desired.

Selenium.—A rare non-metallic element, closely resembling sulphur in its behavior, and found in conjunction with that substance and with tellurium. The electrical resistance of selenium changes remarkably under the action of light, consequently selenium cells are much employed in certain classes of apparatus, notably the *photophone*, where sound is transmitted along a beam of light which is directed upon a selenium cell, the variation in the light altering the current and reproducing the sound.

Selenium Cell.—An arrangement employed in the photopone for the transmission of speech by means of light; it consists essentially of two copper wires wound without contact on a strip of mica, and having the free ends joined to a circuit including a telephone and battery, the spaces between the turns of wire being filled with annealed selenium which responds to the action of light; the *photo-electric cell.*

Selenium Eye.—A model of the human eye constructed for photo-electrical experiment purposes, having a retina of selenium connected in circuit with a battery and galvanometer.

Selenium Photometer.—A photometer having a screen of selenium standardized with reference to a known illumination, devised in an attempt to measure the visual intensity of a light source.

Selenium Resistance.—A resistance which varies with the light, composed of strips of annealed selenium introduced between conducting brass plates.

Self-acting.—Automatic, a term applied to a machine or some section of a machine whose changes are not executed by direct intervention on the part of the attendant, but which are derived immediately from the movements of the machine itself. The chief motions in ordinary machines are rendered self-acting through the intervention of *screws*, *cams*, *gearing*, *levers*, etc.

Self-closing Telegraph Key.—A telegraph key so adjusted that a switch is automatically closed by depressing the key, and opened again when the key is released.

Self-contained.—A term applied to an engine, apparatus or machine, having all its essential working parts contained within the immediate limits of its own frame.

Self-contained Machine.—In machinery, machines whose parts are not attached to distinct fixtures, but are all so combined that one foundation or attachment is sufficient. Thus, a radial drill is self-contained when the table and pillar are bolted together, instead of, as is often the case, the radial arm being attached to a wall or pillar, while the table is bolted to the stone foundation. Independent machines may be considered as self contained.

Self-cooling Transformer.—A transformer which can be sufficiently cooled by contact of its coils with the air, or by merely filling the case with oil, without resorting to a forced circulation.

Self-excitation.—Magnetizing the field magnets of a dynamo by means of currents

generated in its own armature. It is made possible by virtue of residual magnetism in the frame and pole pieces of the machine.

Self-excited Alternator.—An alternating current dynamo which supplies its field magnets with magnetizing currents generated by its own armature, as distinguished from a separately excited alternator.

Self-excited Dynamo.—A dynamo which supplies its field magnets with magnetizing currents generated by its own armature, as distinguished from a separately excited dynamo.

Self-induced Current.—An extra current produced in a circuit, especially in that of a coil of wire, by electromagnetic induction, so that upon closing the circuit an instantaneous secondary current opposes the primary current, and when the circuit is suddenly opened the current is slightly prolonged in its own direction.

Self-induction. — Electromagnetic induction in a circuit, produced by the action of the electric current upon itself during variations in strength; especially in a coil of wire in which the adjacent turns act inductively upon each other upon the principle of the mutual induction arising between two separate adjacent circuits; self-induction gives rise to the *extra* or *induced* currents.

Self-induction Coil.—1. A coil of wire exhibiting self-induction.

2. A name sometimes given to a *choking coil.*

Self-locking Ratchet. — A self-locking winding device employed in raising or lowering an arc lamp suspended from a pole.

Self-oiling Bearings.—Bearings which are provided with a reservoir or cellar for oil underneath the journal; a ring or chain, loosely encircling the shaft, rotates with it and carries up a continuous stream of oil from the reservoir.

Self-recording Magnetometer.—An instrument for automatically measuring and recording the varying intensity of terrestial magnetism.

Self-registering Tachometer.—An instrument for automatically registering the speed of a revolving shaft.

Self-registering Wire Gauge.—A form of wire gauge designed to register automatically the measurement of a wire.

Self-regulating Dynamo.—A dynamo so constructed as to maintain a constant pressure under varying loads.

Self-regulating X-ray Tube.—A vacuum tube in which the degree of exhaustion may be automatically regulated by the action of a suitable chemical contained in an auxiliary tube.

Self-restoring Drop.—In a telephone switchboard or other annunciator, a drop that is mechanically or electrically self-restoring after falling, so that the operator or attendant is spared the labor of returning by hand.

Self-restoring Indicator.—An indicator or annunciator provided with self-restoring drops.

Self-winding Clock.—A clock that is wound at stated intervals by the automatic action of a small electric motor joined to a battery usually contained in the clock itself.

Sellers Thread. — The standard screw thread of the United States, having an enclosed angle of 60° between the threads, and one eighth flattened at top and at bottom, i. e., the thread does not terminate in a sharp edge.

Semaphore.—1. In a railway block system, a standard 'supporting a signaling apparatus, consisting of a system of movable arms for use by day and a set of colored lights for signaling at night.

2. A device sometimes used as an indicator for large charges of electricity. It consists of a pith ball at the end of a light arm fixed on a pivot to an upright. When the whole is electrified the ball is repelled from the upright and flies out at an angle indicated on a graduated dial.

Semaphore Arm.—One of a set of movable arms used in a system of day signaling from a semaphore.

Semaphore Indicator. — An indicator drop connected with a semaphore system of railway signaling.

Semi-circular Deviation or Error.—The deviation of the magnetic needle of a compass due to the permanent magnetism in an iron or steel ship. This error disappears when the ship is in the magnetic

meridian, but twice increases to a maximum and diminishes to zero when the vessel swings through a complete circle.

Semi-conductor.—A name given to substances having only moderate power of transmitting electricity, and which may be said in that respect to stand midway between conductors and non-conductors or insulators.

Semi-incandescent Lamp.—A type of electric lamp which combines the principles of arc and incandescent lighting, having two carbon electrodes between which an arc is formed which at the same time produces incandescence.

Semi-period.—The time required to pass through half a cycle of periodic motion.

Semi-permeable Septum. — A porous partition which will separate a solution by permitting the solvent to pass through it, but not the matter held in solution.

Sending Aerial.—In wireless telegraphy, the sending *antenna* or wire employed to project oscillations into space from the mast.

Sending End.—That end of a telegraph line from which a message is sent; the end at the transmitting station.

Sending Operator.—A telegraph operator who transmits a message.

Sense of Magnetic Force.—A term sometimes used for the directive influence of magnetism upon a magnetic needle.

Sensible Heat.—That part of heat which produces a rise in temperature, as shown by the thermometer, in distinction from *latent heat.*

Sensitiveness.—The degree to which the needle of a galvanometer, or similar instrument, is sensitive to the influence of a passing electric current in producing deflection.

Sensitiveness of Wheatstone's Bridge.—The minimum degree of resistance which a Wheatstone's bridge is capable of measuring.

Sensitive Plant.—It was discovered by Ritter, that the sensitive plant shuts up when electrified. This property, as has been shown by Burden Sanderson, extends to other vegetable growth, being exhibited by the carnivorous plant, the Venus's fly-trap or *dionaea.*

Sensitive Telephone.—A telephone of particularly delicate construction, so that it can respond to feeble vibrations.

Sensitive Tube.—In wireless telegraphy, a term sometimes applied to the *coherer.* It consists of an exhausted glass tube, in which, between two silver plugs provided with terminals, are enclosed a quantity of silver and nickel filings. These filings are sensitive to electric oscillations, cohering when oscillations occur, causing a drop in resistance which operates a relay and gives a signal.

Sent Current.—In telegraphy, a current by means of which a signal is sent out.

Separable Core.—A core, as of an electromagnet, which may be readily withdrawn from the coils.

Separable Plug.—A telephone switchboard plug which may be readily disconnected from the flexible conducting cord.

Separate Circuit Dynamo.—A dynamo in which the field magnet coils are excited by special coils wound upon the armature or upon a separate armature; *a separate coil dynamo.*

Separate Coil Armature.—A dynamo armature wound with a series of coils that are kept distinct from each other instead of overlapping or interlacing.

Separate Excitation.—The excitation of dynamo field magnets from an external and entirely separate source, usually by a small continuous current dynamo called an "exciter," or by a storage battery.

Separate Expansion Valve.—A term denoting the employment of a gridiron valve, controlling the admission of steam only, and working upon a separate face, which divides the valve chest into two portions. This type is rarely used in modern engines, the cut off valve riding on the back of the main valve, which serves as its seat or face.

Separately Excited Alternator.—An alternating current dynamo whose field magnets are excited from an external source, as distinguished from a self-exciting alternator.

Separately Excited Dynamo.—A dynamo whose field magnets are excited from an external and separate source, as distinguished from a self-exciting dynamo.

Separate Touch.—A method of magnetizing a steel bar, in which two bar magnets with their opposite poles near together are brought into contact with the middle of the bar and drawn apart towards the ends and back several times, leaving off at the middle. This method is also called *divided touch.*

Separator.—1. In a storage battery, a perforated partition of insulating material introduced between two plates to prevent short circuiting.

2. A device attached to steam pipes, consisting of a U shaped chamber, furnished with baffles, deflectors and diaphragms, to riddle entrained water from live steam, before it enters the engine, or to separate oily particles from exhaust steam on its way to the condenser. A reservoir is generally provided at the bottom of the chamber, furnished with a gauge glass and drain cocks, the collected liquid being usually automatically removed by a trap.

Septum.—The porous partition or diaphragm through which two liquids intermix in the phenomenon of *osmose.*

Series and Parallel Coupling of Dynamos.—Since the output of a dynamo is made up of two factors, viz.: the pressure and the current respectively, it follows that the output of a machine may be enlarged by increasing either one or the other, or both at the same time. As, however, the systems of distribution in use at the present time involve the maintenance of either a *constant current* or a *constant pressure* in a circuit, the methods of coupling dynamos together resolve themselves into two kinds, corresponding to the systems of distribution, viz.: *parallel* and *series* connections. In coupling two or more machines in parallel, the pressures of all the machines are kept at a constant value, while the output of the plant is increased in proportion to the current capacities of the machines in circuit. In the series coupling, the current capacity of the plant is kept at a constant value, while the output is increased in proportion to the pressures of the machines in circuit.

Series and Separately Excited Dynamo.—A compound dynamo in which the field magnets are connected in series with the external circuit, and at the same time magnetized from a separate source.

Series and Shunt Wound Dynamo.—A compound wound dynamo, having a combination of the series and shunt windings on the field magnet. The shunt winding consists of numerous turns of fine wire so connected as to form a shunt to the external circuit, and the series windings composed of a few turns of thick wire are joined in series with the armature and external circuit.

Series Arc Cut Out.—A cut out sometimes used in connection with a series arc lamp, providing an alternative path of low resistance, so that when a lamp breaks down from any cause the other lamps in the circuit may not be affected.

Series Circuit.—An electric circuit in which all the receptive devices are arranged in succession, as distinguished from a *parallel* circuit. Cells are said to be in series when the zinc of one is connected to the carbon of the next throughout the battery: lamps are in series when the current passes through each one in turn; any group of electric apparatus is joined in series when the positive pole of one machine is connected to the negative pole of the next.

Series Connected Battery.—A battery composed of cells so connected that the zinc of one is joined to the carbon of the next throughout the battery.

Series Connected Cells.—A group of primary cells connected to form a battery in which the zinc of one cell is joined to the carbon of the next in succession.

Series Connected Dynamos.—Two or more dynamos connected with each other *in series.*

Series Connected Lamps.—Electric lamps arranged in succession on a circuit so that the current passes from one to another in turn.

Series Connected Receptive Devices.—A group of receptive devices so connected that the positive terminal of one is joined to the negative terminal of the next through the entire group.

Series Connected Transformers.—Transformers in a system of electric distribution having all their primary coils connected in series.

Series Connection.—A method of connecting up an electric system so that the current passes through each device in the circuit one after the other in direct succession, as when a number of primary cells form a battery by having the copper of one cell joined to the zinc of the next, and so on through the group. In a series connected battery the electromotive force is equal to the sum of the E. M. F.'s of the individual cells.

Series Distribution.—A system of electric distribution in which the receptive devices, such as incandescent lamps, are so connected that the current passes from one to another in succession throughout the circuit.

Series Dynamo.—A dynamo in which the field magnets are wound with a few turns of thick wire joined in series to the armature so that the whole current passes through the coils into the external circuit; the current in passing through the coils of the field magnet energizes the latter, and creates a magnetic field between the two poles N S, in which the armature revolves, a *series wound dynamo.*

Series Lamps.—An occasional connection for electric lamps, in which the same current is led through all the lamps. It is an arrangement sometimes used for street lighting, but rarely for inside work.

Series Motor.—An electric motor in which the field magnet coils are connected in series with the armature; a *series wound motor.*

Series Multiple.—A term used for *series parallel connection.*

Series Multiple Switchboard.—A multiple telephone switchboard in which the line is caused to pass through the spring jacks at the various sections in series.

Series Parallel Circuit.—An electric circuit containing groups of parallel connected receptive devices, the groups being arranged in the circuit in series; a *series multiple circuit.*

Series Parallel Connection.—The arrangement of receptive devices, such as lamps, in an electric circuit in a number of parallel connected groups, these groups, in turn, being connected in series; *series multiple connection.*

Series Parallel Controller.—A controller of a two motor electric car by means of which the motors first in series may afterwards be switched into parallel; a *series multiple controller.*

Series Switchboard.—A multiple telephone switchboard in which connections are made in series.

Series Terminals.—The terminals of the series winding of a compound dynamo or motor connected with the external circuit.

Series Transformer.—A transformer having its primary in series with the circuit, and its secondary in series with the device which receives the current. They are used largely on alternating current switchboards for operating ammeters and wattmeters.

Series Turns.—The few turns of thick insulated wire wound upon the field magnets of a series dynamo, and joined in series with the armature.

Series Winding.—The winding of a series dynamo consisting of a few turns of thick insulated wire wound upon the field magnets and connected in series with the armature, so that the whole of the current passes through the coils into the external circuit.

Series Working of Dynamos.—Operating two or more dynamos connected in series.

Series Wound Field.—The field of a series dynamo in which the whole current generated in the armature passes through the coils of the field magnets.

Serrated.—Toothed or notched along the edge, like a saw. The word is derived from the Latin: *serra*, a saw.

Service.—In electric distribution, a general term for the branch conductors furnishing electric energy to a consumer.

Service Block.—In electric distribution, a branch block containing safety fuses for connecting service wires to a main.

Service Box.—In the conduit system of electric distribution, a shallow metallic box placed at points of distribution to consumers. In this box the branch service cables are attached to the main cables and the space filled with an insulating compound and protected by a cover clamped over it. Service boxes are reached by hand holes.

Service Lines.—Telephone lines between an exchange and its subscribers.

Service Main.—In electric distribution, the wire which leads from the street main

into the consumer's premises; the *consumer's main*, or *service wire.*

Service Tube.—An insulating tube by means of which service wires are led into a building.

Service Wires or Conductors.—In a system of electrical distribution, branch wires leading from the mains to a consumer's premises; service conductors; *delivery wires.*

Serving.—The wrappings of paper or other insulating material applied to the core of a cable before the lead sheath is put on.

Serving Mallet.—A mallet for laying on closely and evenly the coating of jute, paper or other insulating material employed to wrap a cable core before the sheath is applied; *a serving tool.*

Set.—1. To prepare for use; to make ready; as, to bend the teeth of a saw to one side or other from the median line, or to spread thin ends by swaging.

2. Permanent change of figure in consequence of excessive strain; as, from compression, tension, bending, twisting, etc.; as the set of a spring.

3. A kind of punch, used for bending, indenting, or giving shape to metal; as, a saw *set.*

Set Collar.—A collar or ring held on a shaft by set screws, which serves to prevent end play on line shafting, or to make longitudinal adjustments of shafts or spindles.

Set Screw.—A screw with a pointed or cupped end, used to secure a pulley upon a shaft, or for like purposes.

Seven Point Jack.—A telephone spring jack provided with seven contact points.

Sextant.—An optical instrument for measuring the angular displacement between two distant objects; it consists essentially of a pivoted arm traversing a graduated arc and carrying a small mirror, a second mirror fixed upon the frame so as to be parallel with the first when the arm is at zero, and a small telescope directed towards the second mirror.

Sextaplex Telegraphy.—A system of telegraphy by which six messages may be transmitted simultaneously over the same wire, three in each direction.

Sextaplex Transmission.—Transmitting messages by the sextaplex system of telegraphy.

Sextipolar Dynamo.—A multipolar dynamo provided with six field magnet poles.

Sextipolar Field.—An electromagnetic field produced by six field magnet poles, as in a sextipolar dynamo.

Sextuple Telegraphy.—A system of telegraphy in which six different messages may be transmitted simultaneously over the same line in one direction.

Sextuple Transmission.—Transmitting messages by the sextuple system of telegraphy.

S. G.—In submarine telegraphy, a signal prefixed to a message to indicate that the communication relates solely to the company's business.

Shackle.—A form of swinging insulator bracket for use upon a telegraph pole where an angle occurs in the line.

Shackling.—Connecting a line wire to a shackle insulator.

Shade Holder.—Any device for holding a shade over an incandescent or arc lamp.

Shading Coil.—A device for giving a single phase induction motor a starting torque. It consists of a low resistance conductor surrounding a portion of a field pole placed in a slot cut in the pole parallel to the shaft of the rotor.

Shadowgraph.—1. A term sometimes applied to a radiograph, or an X-ray photograph; a *shadowgram.*

2. In testing an electric flatiron, records made at short intervals of the ability of the iron to scorch paper to show its power to hold heat.

Shadow Photometer.—A type of photometer consisting of an upright ground glass screen having a small vertical rod fixed in front of it; the standard light and the source to be tested are caused to throw two shadows upon the screen, and then are adjusted until the intensities of the shadows are alike, when the distances are measured and the comparative luminosities deduced from the law of inverse squares; the *Rumford photometer.*

Shadows, Electric.—The current of electrified air from a charged pointed conductor will produce a charge upon the surface of any insulating body, such as a plate of ebonite or glass, held a few inches away. If a slip of mica or glass be interposed between the surface against which the wind is directed and the point from whence it comes, an electric shadow will be formed on the surface at the part so screened.

Shaft.—1. A bar having one or more journals on which it rests and revolves, and intended to carry one or more wheels or other revolving parts; as, the shaft of a steam engine.
2. A chimney or smokestack.

Shaft Coupling.—A device employed to connect the different sections or lengths of which a line of shafting is composed. There are two classes, those that form permanent connections, such as, *flange, disc, plate,* or *compression* couplings, and those which effect engagement or disconnection between the various lengths at will, such as, *friction* and *jaw clutches.*

Shaft Drive.—Said of a motor car when the power is transmitted directly to the driving axle through gearing or a lay shaft, without the interposition of a chain.

Shaft Governor.—A centrifugal governor for an engine, mounted on a pulley upon the crank shaft and revolving with it. Such a governor acts either by centrifugal force or by the inertia of its parts, and usually controls the travel of the slide valves in a steam engine, or the throttle valve in a gas engine.

Shallow Water Cable.—A cable designed to be laid in comparatively shallow water, and hence specially protected against wear upon a rocky bottom by the provision of extra sheathing.

Shear.—A strain in which a tension in one direction is combined with an equal pressure at right angles to it; a *shearing stress.*

Shearing Strength.—Equivalent to the force which, if steadily and slowly applied at right angles, or nearly so, to the line of axis of a rivet, causes it to separate into parts, which slide over each other, the planes of the surface at the point of separation being at right angles, or nearly so, to the axis of the rivet.

Shear Legs.—In erecting, a tripod crane of tall spars used for lifting heavy weights, adjusted by sliding the back leg in or out on a long screw.

Sheath.—The final protective coating applied to a cable: in the case of aerial cables it is usually of pure lead; in submarine cables it consists of steel sheathing wires covered with hemp.

Sheathing Paper.—A thick paper, sometimes tarred or oiled, used for a lining.

Sheathing Wires.—The coiled steel wires forming the sheath of a submarine cable.

Sheave.—A pulley with a grooved rim over which a rope or chain passes; *sheaves* are placed singly or side by side within a wooden or metal frame, which is termed a *block.*

Shed of Insulator.—The petticoat of a line wire insulator.

Sheet Brass.—In metals, brass rolled into sheets and used for a variety of purposes, chiefly for ornament, covering steam domes, gauges, handrailings, instruments, etc. It is either *hard* or *soft,* according to requirements.

Sheet Lightning.—A form of lightning seen as a broad flash illuminating a large area of the clouds, and apparently unaccompanied by thunder, probably due to reflection from a distant storm.

Sheet Metal Gauge.—An instrument employed to measure the thickness of sheets of metal, usually denoting the various thicknesses by a range of successive numbers.

Sheet Piling.—Timbers, piles, or plates of metal or reinforced concrete, driven firmly, side by side in rows, into the earth along the shores of a body of water. The object of sheet piling is either to exclude water or to protect the bank from caving.

Sheet Steel.—Sheets of steel employed to build up parts of electric machines in order to reduce the circulation of eddy currents. The steel employed is very ductile, possesses very high permeability and low hysteresis coefficient, and is very carefully annealed.

Sheet Tin.—In metals, sheet iron coated with tin. It is used by engineers in the making of the lightest kinds of templates, etc.

Shellac.—A commercial form of a resinous substance found upon certain tropical trees, and prepared for the market in thin shells; when dissolved in alcohol it forms shellac varnish, which is useful in electrical work for its insulating properties.

Shell of Arc Lamp.—A term sometimes applied to the frame of an arc lamp.

Shell of Commutator.—A commutator considered apart from the shaft upon which it rotates.

Shell of Lamp Fixture.—An exterior finish of light metal applied to an electric lamp fixture by way of ornamentation.

Shell Transformer.—A transformer in which the coils are within the core, and the external parts consisting of iron discs or a winding of iron wire form a sort of shell in which parts of the coils are embedded, as distinguished from a *core* transformer.

Shift.—1. A number or body of men acting as relays or working alternately with another body carrying on the same work; as, a day shift, a night shift.

2. The period of time through which such a relay works.

Shifting of Spot of Light.—In a mirror galvanometer, any irregular deflection of the spot of light from the zero of the scale, due to imperfect adjustment or other fault.

Shifting Zero.—An irregular displacement of the true zero of a scale, which sometimes leads to error in electrical measurement.

Shim.—1. A piece of wood or iron inserted in a defective place to fill out to a fair surface.

2. To hold in position by means of a *shim.*

Ship Dynamometer.—A dynamometer used on a cable ship to determine the strain put upon a cable in the process of paying out.

Ship Return Circuit System.—A single wire type of electric circuit used on ship board in which the circuit is completed by the metallic hull of the vessel.

Shock, Electric.—A painful and sometimes dangerous shock to the human system produced by a discharge through the body of static or current electricity, especially when of high voltage. The effect experienced by the discharge of electricity with high potential difference through the animal system is that of a sharp and painful *shock;* pain and violent muscular contraction accompany it. The voltage is the main element of shock, amperage has also some direct influence. The condition of the body after death by electric shock corresponds exactly with that found after death by asphyxia. The electric shock paralyzes or destroys the nerve centre which controls the respiratory movements; the passage of venous blood into the arterial system causes contraction of the arterioles. and finally stoppage of the heart exactly as in death by drowning or suffocation. There is, therefore always hope of resuscitation, except when the respiratory nerve centre has been destroyed.

Shoe.—In the third rail system of electric traction, the conducting surface that is brought to bear upon the power rail to draw current into the car motors. There are two chief types, the *link* shoe and the *slipper* shoe.

Shoe Contact.—In the third rail system of electric traction, cast iron rubbing shoes carried on insulated spring supports, by means of which electric contact is made with the third rail.

Shoe Plug.—A variety of telephone switchboard plug with sliding contact.

Sholes.—In erecting, wedges, etc., under the heels of shores.

Shore End of Cable.—The end of a submarine cable approaching the land, generally having extra armor to protect it against special wear.

Short.—A contraction sometimes used among repair men for *short circuit.*

Short Arc System.—An electric lighting system employing short arcs between the carbons.

Short Circuit.—1. A connection of low resistance joining two parts of an electric circuit so as to offer an alternative path for the current when it becomes necessary to cut out that part of the main circuit intercepted by the shunt.

2. A fault in an electric circuit or apparatus due usually to imperfect insulation, such that the current follows a by-path and inflicts damage or is wasted.

Short Circuited Transformer.—A transformer having its secondary terminals short circuited by a copper wire and an ampere meter.

Short Circuiting.—Cutting out of a main circuit by the intentional or accidental introduction of a conducting by-path.

Short Circuiting a Dynamo.—Cutting a dynamo out of a circuit by short circuiting its terminals.

Short Circuiting Plug.—A plug by means of which a short circuit is effected.

Short Circuit Key.—A key by means of which an electrical instrument, such as a galvanometer, may be cut out of a circuit.

Short Circuits in Armature Coils.—This is a common fault, which makes its presence known by a violent heating of the armature, flashing at the commutator, flickering of the light, and by a smell of burning varnish or overheated insulation. The fault is due either to metallic dust lodging in the insulation between adjacent bars of the commutator, or to one or more convolutions of the coils coming into contact with each other, either through a metallic filing becoming embedded in the insulation or damage to the insulation. If the machine will not build, and it is suspected that the fault arises from short circuited armature coils, the field magnets should be excited by the current from a storage battery or another dynamo, and having raised the brushes from contact with the commutator, the armature should be run for a short time. In stopping, the faulty coil or coils may be located by the heat generated by the short circuit.

Short Closed Circuit.—A series circuit having some of its receptive devices disconnected, as distinguished from a *long closed circuit.*

Short Coil Magnet.—An electromagnet wound with a few turns of heavy wire for use in circuits having low resistances.

Short End of Battery.—In quadruplex telegraphy, the smaller portion of the divided battery; the *reduced battery.*

Short Fall Air Pump.—A type of mercury air pump in which the length of the shaft containing the mercury column is shortened, being sometimes arranged in three tubes, 10 inches long, enclosed in a partially exhausted chamber.

Short Magnet.—A magnet whose length is less than fifty times its diameter.

Short Shunt Compound Winding.—A method of compound winding in which the shunt winding is connected directly with the armature from brush to brush.

Short Shunt Compound Wound Dynamo.—A compound wound dynamo employing the short shunt arrangement of the shunt winding.

Short Shunt Dynamo.—A compound wound dynamo in which one terminal of the shunt field coil is connected between the armature and the series coil, as distinguished from *long shunt* in which the terminals of the shunt coil are connected to the outside terminals of the machine.

Short Timber.—Timber, such as wood for telegraph poles, that has been weakened by an over application of preservatives.

Shower Bath, Electric.—In electrotherapeutics, a shower bath of slightly alkaline water by means of which an electric current is conveyed to a patient who is supported on a metallic stool connected with a terminal of the circuit.

Shunt.—1. In an electric circuit, a branch conductor joining the main circuit at two points and forming a parallel or derived circuit, so that the current is divided, a part passing through the branch and a part through the main circuit.

2. To introduce a shunt into an electric circuit.

Shunt Bell.—An electric bell connected in shunt with a circuit.

Shunt Box.—A resistance box containing coils of known resistances employed with a galvanometer so that only a definite fraction of the current shall pass through the instrument; a *shunt rheostat.*

Shunt Breaking Resistance.—A resistance introduced into the field rheostat of a shunt dynamo when a large part of the load is suddenly removed, to prevent the increase in voltage from endangering the devices still in the circuit.

Shunt Circuit.—A *shunt;* a by-path provided in an electric circuit so that only a portion of the current shall pass through it. A shunt is employed with dynamos, motors and electrical instruments for deflecting a small part of the current where the entire current strength is not required.

Shunt Coil.—A coil joined in parallel as a shunt to an electric circuit.

Shunt Dynamo.—A dynamo having a field winding consisting of many turns of fine wire connected in parallel, or as a shunt, to the external circuit, and so connected to the armature brushes as to obtain a portion of the armature current for maintaining the field.

Shunted Field Windings.—The object of using a shunted circuit for the windings of field magnets of dynamos is that the machine may more readily excite its own fields at starting, and that the current may be produced before the rotating armature has fully taken up its speed. Some dynamos have their fields excited by a separate source of electrical energy, in which case the magnet windings are not connected to the brushes' ends on the armature, but direct to the terminals of the outside source of electrical energy. As a usual thing, however, it is unnecessary to use a separate source of current for exciting the magnetic fields, since there is a sufficient amount of residual magnetism, acting between the poles of the magnets, to start the generation of electrical energy as soon as the armature begins to rotate.

Shunt for Ammeter.—A shunt of low resistance and small temperature coefficient introduced into the circuit of an ammeter in order that the current flowing in the moving coil of the instrument may be proportional to that in the main circuit. The shunt consists of two heavy terminal blocks of copper or brass between which are brazed thin sheets of resistance metal such as manganin or constantan, offering a large radiating surface to the air.

Shunt for Galvanometer.—A shunt having a small temperature coefficient of resistivity employed to increase the range of a galvanometer. When the resistance of the galvanometer circuit is not too small, an ordinary resistance box may be used. The *Ayrton* or *universal* shunt is designed for use with any galvanometer by inserting plugs between different terminals, the coils being so arranged that their relative multiplying powers are always the same, whatever the actual resistance of the galvanometer may be.

Shunting Air Gap.—An air gap surrounding an electrical instrument to protect it from the danger of injury from a disruptive discharge.

Shunt Lamp.—A type of series arc lamp in which the length of the arc is maintained by means of a solenoid consisting of many turns of fine wire connected in shunt with the arc, and acting against a spring.

Shunt Motor.—A motor having its armature windings connected in parallel with its field magnet windings.

Shunt Ratio.—The ratio between the fraction of the current passing through a shunt and the total current strength of the circuit.

Shunt Turns.—The number of ampere turns in the shunt windings of a dynamo.

Shunt Winding.—Such a winding of the field magnets of a dynamo as to divide the armature circuit, leading a part of the current through the field coils.

Shunt-wound Dynamo.—A generator in which the field magnet coils, instead of being joined up in series with the armature and external circuit as in a *series-wound* dynamo, are so connected that they form a shunt to the external circuit. The coils are made of a large number of turns of comparatively fine wire which receive only a part of the current generated in the armature.

Shunt Wound Field.—The field of a shunt dynamo in which a portion of the current generated in the armature is led through the field coils forming a shunt to the main circuit.

Shunt-wound Motor.—A motor having its field coils wound with many turns of comparatively fine wire as in a shunt dynamo, only a small part of the current passing through the coils. Shunt-wound or *shunt motors* as they are often called, are used on constant potential circuits, the motor being connected directly across the mains when running. They are self-regulating, so that the speed remains constant under variations of load.

Shutter Apparatus.—An arrangement for signaling by a system of shutters for displaying and shutting off a light, according to a code.

Shutter Drop.—A device for displaying a number, name or symbol in a telephone or other annunciator for indicating the source of a call. The shutter is released by the action of an electromagnet, and is manually restoring or self-restoring according as it is designed to be restored by hand or automatically when the answer is made.

Shutting Down Dynamo.—The load should first be gradually reduced, if possible, by easing down the engine; then, when the machine is supplying little or no current, the main switch should be opened. This reduces the sparking at the switch contacts, and prevents the engine racing. When the voltmeter almost indicates zero, the brushes

should be raised from contact with the commutator. The commutator brushes should not be raised while the machine is generating any considerable voltage; for not only is the insulation of the machine liable to be damaged by this proceeding, but in the case of large shunt dynamos an exceedingly violent shock is liable to be administered to the person lifting the brushes.

When the dynamo is at rest, or only revolving slowly, and the brushes are raised from the commutator, the latter should be cleaned, if necessary. When the machine is stopped it should be thoroughly cleaned up. The armature should be dusted with a pretty stiff brush to remove any adherent copper dust, dirt, etc., and the other portions of the machine should be thoroughly wiped with linen rags. Waste should not be used, as it is liable to leave threads, fluff, etc, on the projecting parts.

Shuttle Armature.—A form of armature of the drum type with a two part commutator, and wound with a single coil in two longitudinal grooves in a shuttle shaped core; the original form of Siemen's armature; an *H armature.*

Side Bar Motor Suspension.—A method of suspending a motor on a car truck by employing two parallel bars fixed at right angles to the shaft and resting upon a frame carried by the truck.

Side Bracket.—A form of bracket for supporting a single insulator upon the side of a pole or building.

Side Commutator.—A commutator carried on the side of a dynamo armature.

Side Flash.—A lateral discharge in the form of a bright flash taking place from a conductor in which a current due to a static discharge is passing.

Side Lights, Electric.—Electric lamps in colored lanterns carried as side lights upon a locomotive or ship.

Side Play.—Provision for longitudinal movement; as, of a shaft in its bearings, or of a working part on the shaft; it is advisable and necessary, so as to permit the parts to adjust themselves while running.

Side Pole Trolley System.—A system of line construction for trolley railways in which the trolley wires are supported by poles set along the side of the street, as distinguished from a center pole system.

Sidereal.—In navigation, of or pertaining to the fixed stars. *Sidereal time* is measured by the apparent diurnal motion over the stars, the sidereal day being measured by the apparent passage over the meridian of the first point of Aries, or first point of right ascension. This is the only correct standard whereby time can be measured.

Sides of Three Wire System.—The positive and negative mains in the three wire system of electric distribution.

Side Telegraph Repeater.—A telegraph repeater working branch lines.

Siemens Armature.—An early form of dynamo armature devised by Werner Siemens in 1856, and commonly known as the *shuttle* armature. It consisted of a considerable length of silk or cotton covered copper wire wound in grooves of a shuttle-shaped piece of iron.

Siemens Calorimeter.—An instrument for high temperature measurement consisting of a metal cylinder containing water in which is submerged a metallic ball, the whole connected with a thermometer graduated to read directly the temperature reached by the heated ball.

Siemens Differential Voltameter.—A form of gas voltameter invented by Siemens for measuring the resistance of the platinum coil used in his pyrometer.

Siemens Electro-dynamometer.—An instrument for measuring currents, E. M. F.'s and power on both direct and alternating current circuits. The working parts of the instrument consist of two rectangular coils of wire, one fixed and the other suspended from a torsion head, with the plane of its windings at right angles to that of the fixed coil. When the current passes, the movable coil tends to turn and is brought back to its original position by the graduated head. The amount which the head is turned is proportional to the couple required to bring the coil back to its zero position and therefore to the product of the currents in the two coils.

Siemens Electro-pyrometer.—An instrument for measuring high temperatures consisting essentially of a fine platinum wire wound on a cylinder of porcelain or fire clay, and the whole enclosed in an iron tube.

Siemens-Halske Cell.—A variety of Daniell cell employing a zinc-copper couple, the zinc being supported in a bell shaped inner jar upon a mass of paper pulp moistened with dilute sulphuric acid.

Siemens, Ernst Werner Von.—Born 1816, died 1892. A German electrical

engineer, brother of Sir William Siemens. He early applied himself to the study of chemistry and electromagnetism, inventing a process of electroplating in 1841. In 1848 he exploded a submarine mine for the first time by means of an electric current. The following year he began to devote himself to establishing telegraph systems in various parts of Europe. He invented an improved form of shuttle armature in 1856, which was known as the Siemens armature, and discovered the principle of dynamo operation (1867). He was the promoter of electric traction in Germany (1879) establishing the famous engineering firm of Siemens & Halske. His experiments resulted in the discovery of many facts of great value in electrical practice and the development of important apparatus. In 1884 he contributed a large sum of money to establish the Imperial Physico-Technical Institute which has been a great factor in German engineering progress.

Siemens, Sir Karl William.—Born 1823, died 1883. A German-English metallurgist and electrician, promoter of electrical enterprises in England, brother of E. W. von Siemens. He first visited England in 1843 to introduce a chronometric governor for steam engines and the process of anastatic printing; settling in England, he patented a regenerative steam engine and condenser (1847), a water meter (1851), and organized a company for the manufacture of steel; he became London agent for the German electrical firm of Siemens & Halske, and played an important part in the development of electric lighting and traction in England; he laid an Atlantic cable from a ship specially designed by him (1874-75); he invented the electric furnace (1879), the pyrometer, the bathometer, taking out in all 113 patents; he became president of four leading English engineering societies, received many honors and distinctions, culminating in knighthood the year of his death.

Sight Feed Oiler.—An oil cup made of glass so that the attendant may readily watch the lubrication of the machine.

Signal.—In railroading, a semaphore or other sign automatically set by a train in passing over the track to prevent another train from following it too closely on the same track, a *block signal.*

Signal Arm.—In a system of railway signaling, a *semaphore* arm, a narrow blade pivoted near one end to an upright post. The short end of the arm is provided with holes fitted with colored bulls'-eyes for night service, showing red light for danger and a green light for clear. The long blade usually points horizontally for danger and downwards for clear, though certain systems require other positions, such as 45 degrees caution, and vertical clear, but the danger signal is always horizontal.

Signal Lamps for Switchboards.—In many telephone exchanges, small incandescent electric lamps used for calling signals. These lamps are superior to drops in that they need not be "restored," the light being extinguished so soon as the proper connections are completed, and also from the fact that they occupy less room on the panel, a consideration of importance in the construction and operation of multiple switchboards of large capacity.

Signaling Relay.—A device employed in telephone and telegraph work for opening or closing a local circuit according to certain electrical conditions in the main circuit, and acting to transmit signals from the main to a secondary circuit.

Signal Service System.—A system of electric signaling employed to safeguard a railway line.

Signature.—The portion of a telegraph message giving the name of the person sending it.

Silence Cabinet.—A telephone booth or closet provided at a public pay station so that the telephone may be used without being overheard.

Silencer.—A device for silencing the noise of the exhaust from an internal combustion engine, by muffling and cooling the gases until they have condensed approximately to near their original volume; also called *muffler.*

Silent.—A switch by means of which an electric alarm may be kept from ringing by cutting it out of the circuit.

Silent Discharge.—A discharge of electricity which takes place from the tip of a pointed conductor when the charge has accumulated there with so great density as to electrify the surrounding air. The particles of air fly off by repulsion and convey a part of the charge with them. It is usually known as a *convective* discharge and acts silently in contrast with the noise of a *disruptive* discharge.

Silex.—In chemistry, an oxide of silicon. It occurs nearly pure in quartz rock, chalcedony, flint, and in various other more or less impure forms; it constitutes an important part of the earth's crust; also called *silica.*

Silica.—In chemistry, an oxide of silicon, known also as *silex.*

Silicon.—Also called silicium. A non-metallic element, widely diffused through

nature, forming in various compounds most of the rocks constituting the earth's crust. Its name is derived from the Latin, *silex*, a flint, a familiar manifestation. A small quantity added to copper deprives it of oxygen, improving it for *telegraph* or *telephone wire*. In cast iron, it increases hardness, and with cast steel, a small percentage favors the expulsion of gases and promotes sound castings free from blow holes. In its most usual form as silica or silicon dioxide, it forms the ruby, the quartz of the mountain, and the sand of the seashore.

Silicon Bronze.—An alloy of copper and silicon, with or without tin. Silicon gives to copper great strength and toughness; used for telegraph and telephone wires, principally in German and Austrian cities,

Siloxicon.—A very refractory compound of silicon, carbon and oxygen prepared in the electric furnace.

Silver.—A precious metal of a white lustrous appearance, having a specific gravity of 10.56 and a melting point of 1733° Fahr. Silver is the best conductor of electricity. It is soft and can be beaten out into extremely thin leaves (*silver leaf*); it requires the addition of copper to make it hard enough for general use; as, *sterling silver*, consisting of .925 silver and .075 copper. The metal does not oxidize at any temperature in the air, but it is blackened by sulphuretted hydrogen, hence, polished silver articles tarnish when exposed to the air. Silver is found free in various parts of the world, as a chloride or horn silver, and in various sulphides.

Silver Bath.—A bath for silver plating containing a solution of a silver salt, usually cyanide of silver formed by the union of silver and prussic acid.

Silver Chloride.—A heavy white powder which by exposure to light becomes finally black. It is practically insoluble in water, but dissolves easily in liquid ammonia and in potassium cyanide solution. In electroplating it is employed in the preparation of baths for silver plating. It is also used for silvering by boiling, and in the pastes for silvering by friction.

Silver Chloride Cell.—A form of voltaic cell specially adapted for electric testing, consisting of a zinc silver couple in an electrolyte of sal ammoniac.

Silvered Plumbago.—Powdered graphite combined with silver sometimes applied to a mould in order to give it a conducting surface preparatory to electrotyping.

Silver Palladium Alloy.—A non-magnetic alloy of silver and palladium sometimes used for the delicate parts of a watch to prevent magnetization.

Silver Plating.—Electroplating articles composed of a base metal with a coating of silver by immersing them in a silver bath opposite sheets of silver which form the anodes of the electrolytic cell, the articles to be plated being the cathodes; when the electric current passes, the silver of the anodes is decomposed and is deposited upon the cathodes in a uniform layer.

Silver Voltameter.—An instrument for determining the value of an electric current by the weight of silver deposited in the process of electrolysis performed by the current through an anode of pure silver in a solution of silver nitrate.

Similar Poles.—In magnetism, similar poles are magnetic poles of the same sign; also called *like poles*.

Simple.—In chemistry a term indicating not capable of being decomposed into anything more simple or ultimate by any means at present known; elementary; thus, *atoms* are regarded as simple bodies.

Simple Alternating or Periodic Currents.—The same as *simple harmonic* currents.

Simple Arc.—An electric arc maintained between two electrodes.

Simple Cell.—The simplest form of primary or voltaic cell, in which two electrodes are immersed in a single fluid.

Simple Circuit.—An electric circuit formed by a single conductor including one generator and a single receptive device.

Simple Harmonic Currents.—Electric currents which rise and fall in strength at regular intervals so that the characteristic of the current flow may be traced in a simple harmonic curve; *simple periodic* or *sinusoidal* currents.

Simple Harmonic Electromotive Forces.—Electromotive forces which rise and fall in strength at regular intervals, producing simple harmonic currents.

Simple Harmonic Motion.—Regular to and fro motion upon a straight line, as that of a long pendulum swinging over a small arc of vibration; *simple periodic motion.*

Simple Harmonic Variation.—The regular variations in strength and duration which characterize simple harmonic currents; a *sinusoidal variation.*

Simple Immersion.—A method of obtaining a metallic coating upon an article by simply dipping the article in a bath of melted metal.

Simple Magnet.—A magnet consisting of a single metallic bar, as distinguished from a compound magnet.

Simple Magnetic Shell.—A magnetic shell having a uniform distribution of magnetism upon each of its faces.

Simple Periodic or Sine Motion.—The same as *simple harmonic motion.*

Simple Radical.—A single atom of matter considered apart from any chemical composition which it may enter.

Simple Shunt.—A simple coil of wire without an iron core, introduced as a shunt to an electric circuit.

Simplex Telegraphy.—A system of telegraphy in which only one message can be sent over the line at a time.

Simplex Two-circuit Winding.—A form of armature winding having only two paths through the armature, and requiring only two sets of brushes, whatever the number of poles. The pitch is always forward instead of alternately forward and backward as in multiple-circuit winding.

Simplex Working.—Telegraphic transmission in which only one message at a time is sent over the line.

Simultaneous Telegraphy and Telephony.—Transmission of telegraph and telephone messages over the same line at the same time. The *simplex system* permits one message of each kind at the same time.

Sine Curve.—A wave like curve used to represent the changes in strength and direction of an alternating current. The current begins at zero, rises to a maximum, decreases again to zero, and increases to a maximum in the opposite direction, tracing a waving line in which the horizontal distances represent time and the vertical distances represent the varying values of E. M. F. It is called a *sine curve* because its perpendicular at any point is proportional to the *sine* of the angle corresponding to that point.

Sine Galvanometer.—A form of galvanometer consisting of a circular coil rotating about a vertical axis passing through the suspension of a long needle carried at the center of the coil. A current flowing through the coil deflects the needle and turns the coil, so that the sine of the angle through which the coil is moved is proportional to the strength of the current.

Sine Law.—A law that the force acting upon a body is directly proportional to the angle of deflection if, (a) the controlling force has constant magnitude and direction, and (b) the deflecting force is uniform in direction with respect to the body acted upon.

Singing Arc.—A voltaic arc fed by a continuous current which is placed under suitable conditions near an alternating current of small intensity, so that the arc emits a sound corresponding to the oscillations of the alternating current, and the light of the arc produces equal vibrations.

Single Circuit.—An electric circuit containing no branch circuits, as distinguished from a divided circuit.

Single Contact Carbon Transmitter.—A form of telephone transmitter depending upon the change of actual resistance of a single button of carbon under varying pressure.

Single Contact Key.—A key for opening and closing a circuit which has only one contact point.

Single Belting.—Leather belting made in one thickness or ply, such as is used for driving small machines.

Single Cup Insulator.—A line wire insulator of the simplest form; a *single shed insulator*.

Single Curb.—A method of submarine telegraphic signaling in which a single weak reverse current is sent immediately after the original signal for the purpose of hastening it through the cable.

Single Curb Signaling.—Using the single curb method of submarine telegraphic signaling.

Single Current Closed Circuit Working.—A method of telegraphic working employing a single current, and preserving the batteries at the terminals of the line constantly in circuit.

Single Current Key.—A telegraph key employed in single current working, consisting of a brass lever pivoted between two contacts, but normally held against the back contact by a spring.

Single Current Open Circuit Working.—A method of telegraph working employing a single current, in which no current passes when the circuit is idle.

Single Current Repeater.—A telegraph repeater employed in single current working.

Single Current Working.—Telegraphic transmission employing a single current in the circuit.

Single Curve Suspension.—A method of suspending a trolley wire by means of properly adjusted pull off wires where the track makes a curve.

Single Field Coil Dynamo.—A dynamo having its field magnet wound with a single coil of wire.

Single Field Coil Multipolar Dynamo.—A dynamo in which a single magnetizing coil is employed upon a single core which carries several pole pieces.

Single Fluid Cell.—A simple primary cell employing a single solution as an electrolyte.

Single Fluid Theory.—A theory suggested by Franklin as a modification of the double fluid theory previously advanced. He proposed that electricity existed in nature as a single fluid showing positive and negative characteristics under varying conditions.

Single Focus X-ray Tube.—A form of X-ray tube having a single anticathode upon which the cathode rays are focused.

Single Line Repeater.—A telegraph repeater for repeating a message from one circuit into one other only.

Single Loop Armature.—A simple form of armature consisting of a single loop or coil mounted upon an axis so that it may rotate in a magnetic field.

Single Needle Telegraphy.—In the needle system of telegraphy, the use of a receiving instrument comprising a single magnetic needle which swings over the face of a dial according to a definite code of motions.

Single Pair Brush Rocker.—A yoke rocker for holding a single pair of brushes against the surface of a commutator.

Single Peg.—A conducting peg or pin having one contact point for closing a circuit.

Single Phase.—A term applied to a simple alternating current of uniform frequency as distinguished from polyphase currents; *monophase*; *uniphase.*

Single Phase Alternating Current.—A simple alternating current of uniform frequency as distinguished from polyphase currents.

Single Phase Alternator.—An alternating current dynamo generating single phase currents; *a uniphaser.*

Single Phase Armature Windings.—Windings upon the armature of a single phase alternator capable of producing single phase currents.

Single Phase Induction Motor.—An induction motor having a single field winding supplied with a single phase current.

Single Phase Motor.—An ordinary single phase alternator employed as a motor, having a single field winding fed with a single phase current.

Single Phaser.—A single phase alternator; *a uniphaser.*

Single Phase Transformer.—A transformer in a single phase circuit.

Single-phase Winding.—A method of armature winding designed for single-phase generators. Such windings usually have one group of coils per pole lying in an even number of slots per pole.

Single Pole Cut Out.—A cut out which acts only on one of the leads or conductors in an electric circuit.

Single Pole Safety Fuse.—A safety fuse or strip employed in a single pole cut out.

Single Pole Switch.—A switch which controls only one of the leads of a circuit.

Single Pole Telephone Receiver.—A form of telephone receiver containing a compound magnet composed of several separately magnetized steel bars, presenting one pole only to the diaphragm, as distinguished from *a bipolar receiver.*

Single Pole Telephone Switch.—A single pole switch for use in a telephone circuit.

Single Pull Over.—A form of trolley hanger designed to suspend the trolley wire at a curve, provided with a single extension lug for the attachment of a strain wire.

Single Purchase.—In rigging, gear for lifting or other purposes in which one pinion and one wheel only, that is a single gear, are engaged.

Single Rail Crane.—A light workshop crane, which runs on a single rail embedded in the floor. It is maintained in a vertical position by means of wheels running on channel iron hung from or attached to the roof.

Single Reduction Gear.—A method of gearing the armature shaft of a car motor to the axle of the car, by means of a pinion on the motor shaft and a spur wheel on the axle, so that the speed is reduced once only.

Single Reflection Tube.—A simple form of X-ray tube having a single platinum reflector upon which the cathode rays are directed to produce the radiation.

Single Riveting.—Single riveting consists of a single row of rivets. Usually all girth seams, those running around the body of the boiler, are single riveted. The size of the rivets should be in proportion to the thickness of the metal of the shell.

Single Shackle.—A form of swinging telegraph insulator providing for only a single attachment.

Single Shed Insulator.—The simplest form of line wire insulator. It is usually of glass, shaped like an inverted deep cup with a single rim.

Single Stroke Electric Bell.—An electric bell that rings one stroke only when the circuit is closed, as distinguished from a vibrating bell.

Single Throw Switch.—A knife switch with a single set of contacts for controlling one circuit only.

Single Touch Magnetization.—A method of magnetizing a bar of iron or steel, which consists simply in stroking the bar from the middle to each end with a permanent magnet. Opposite poles of the magnet are used for opposite ends of the bar, the stroking always passing from center to end, the return to the center in all cases being made through the air.

Single Track Bracket Suspension.—In a single track trolley line a method of suspending the trolley wire by bracket arms carried on posts.

Single Trolley System.—An earth return trolley system having a single overhead conductor.

Single Wire Cable.—A cable containing a single conductor only instead of a group of conductors as in a bunched or stranded cable.

Single Wire Circuit or Line.—An earth return circuit employing a single conductor.

Single Wire Electric Lighting System.—A system of distribution for electric lighting employing a ground return.

Single Wire Spring Jack.—A form of spring jack adapted for use in a single wire switchboard.

Single Wound Gramme Armature.—A ring armature wound with a single coil of copper wire connected at equal intervals with segments of the commutator.

Single Wound Wire.—A conductor wrapped with only one layer of insulation.

Sinistrorsal Helix, or Solenoid.—A *left-handed* helix; a long spiral of wire in which the current flows in the opposite direction to that followed by the hands of a clock, developing north-seeking polarity at the end at which it enters and south-seeking polarity at the opposite end.

Sinuous Current.—An electric current flowing through *a spiral conductor.*

Sinusoidal Alternator.—An alternating current dynamo which generates simple harmonic or *sinusoidal currents.*

Siphon.—1. A pipe bent in the form of U or ∩ acting on the principle of the hydrostatic balance, so that the pressure of water in one leg always tends to equalize that in the other.

2. A bent tube or pipe with limbs of unequal length for transferring liquids from a barrel or other receptacle. The action of the instrument is due to the difference in weight of the liquid in the two legs.

3. A U shaped tube fitted to steam gauges, etc., so that nothing but water shall enter the gauge.

Siphon Gauge.—A gauge formed of a bent or U shaped tube in which the pressure is shown by the difference in level between the fluid in either leg. Siphon gauges with a mercurial column are employed to test or standardize dial gauges, while a siphon with water for its fluid, is the customary instrument for measuring air pressures.

Siphon Recorder.—In submarine telegraphy, a delicate automatic receiving instrument invented by Lord Kelvin. It consists essentially of a fine coil of wire suspended between the poles of a powerful magnet, and carrying a glass siphon one end of which dips into an ink well. As the current enters the coil, oscillations are set up, which, being conveyed to the siphon, cause it to trace upon a paper ribbon an irregular line corresponding to the dots and dashes of the Morse code.

Siphon Writing.—The record of a telegraphic message traced upon a paper strip by *a siphon recorder.*

Sirius Colloid Lamp.—A variety of incandescent lamp having a filament prepared by a colloidal process. The makers claim for it a specific consumption of 1.15 watts per candle for a guaranteed life of 1000 hours.

Site.—A locality or situation; the place whereon any building or collection of buildings has formerly stood, stands, or is intended to stand; the plot of ground where anything is to be built, made or done.

Six Phase System.—A system of electrical distribution of polyphase currents, consisting of two three phase systems in opposition to each other.

Six Pole Dynamo.—A dynamo provided with six pole pieces for generating its magnetic field; a *sextipolar* dynamo.

Sixteenth Bend.—In pipe fitting, a pipe bend which makes an arc of 22½ degrees and which, therefore, connects pipes which diverge at that angle.

Six Wire System.—A system of electrical distribution including five dynamos joined to *six leads.*

Six Wire Three Phase System.—A three phase system maintaining three circuits of *two wires each.*

S Joint.—A method of connecting two surfaces, which are at right angles to each other, by means of a doubly bent strip, somewhat like the letter S reversed.

Skeleton Construction.—A method of building tall structures on valuable city lots, to avoid wasting too much floor room on thick masonry walls. The building is constructed as a skeleton of steel columns and girders, upon which brick work and terra cotta tiling are hung.

Skeleton Girder.—In structural iron, a girder made by uniting top and bottom angle irons with lattice work or diagonal bracing, the other flanges of the angle irons being attached by riveting to top and bottom plates.

Skew Adjustment of Carbons.—A method of adjusting the carbons of an arc lamp in which the positive point is set out of perpendicular with, and slightly in front of, the negative point.

Skew Arch.—An arch which is not at right angles to its abutments; an archway placed slanting to the road crossing.

Skew Gearing.—Cog wheels with teeth placed obliquely, so as to slide into each other and avoid clashing. They serve to transmit motion from one shaft to another when the two form an angle but would not intersect if prolonged.

Skew Scale.—On a galvanometer, an outer scale known as a skew scale from the position of the needle when at zero; its advantage lies in the fact that its range of measurement is double that of the ordinary scale. For a comparatively high reading, the deflection can be read with greater ease, as the pointer is not in the part of the scale where the divisions are close together.

Skiagraph.—A name sometimes given to a *radiograph*, the image of an object produced on a photographic plate by the X-rays.

Skidding.—1. In electric traction, the slipping of car wheels along a track instead of rotating properly.

2. In automobiling, the sliding or slipping sideways in turning curves at high speed.

Skidding Engine.—In hoisting engines, those engines whose foundation consists of large wooden skids. They are used in construction work where a repeated moving of the engine is required.

Skin.—In mechanics, the thin film or coating of very hard metal on the outside of a casting or forging, due to the chilling or hardening of the surfaces in contact with the sand of the mould or from contact with the air. In machining, it is necessary to take the first cut deep enough to pierce this skin, while if the piece has to be chipped, the prior use of a chipping chisel or of a grinder is necessary.

Skin Currents.—1. High frequency alternating currents which are confined mainly to the outer surface of the conductor instead of passing uniformly through the cross section of the wire.

2. In the human skin and more especially in the skin of the common eel, there is an electromotive force exerted from without, inwards.

Skin Effect.—In high frequency alternating circuits, the tendency of the currents to confine themselves to the outer surface of the conductors instead of passing uniformly through the cross section. The fact that oscillatory currents are greatest at the skin, gives the strongest support to the modern view that the energy in an electric circuit is transmitted by the surrounding medium, and not through the wire.

Skin Electromotive Force.—The electromotive force in a high frequency alternating current producing skin currents.

Skipping of Pointer.—In needle telegraphy, an irregular action of the pointer upon the face of the dial.

Skotogram or Skotograph.—A rarely used term for *radiograph*, an X-ray photograph.

Sky Rods.—In wireless telegraphy, groups of electric conductors supported on lofty masts for the purpose of radiating into space electromagnetic waves conveying the signals; or, at the receiving station, for gathering the waves so sent and carrying them to the receiving instrument; the *antennae*; also called *aerials* or *aerial conductors.*

Slack Cable.—In submarine cable laying, an excess of cable length freely paid out to prevent strain upon the cable as it rests upon an uneven bottom.

Slack Fit.—In shop practice, a fit is said to be slack when parts in contact have more freedom of play than is necessary or desirable for their free and easy movement. The term is relative, because what would be a slack fit in some portions of a machine, would be too tight a fit in another. A slack fit in many cases would more properly mean a bad fit, as in the case of the fitting of shafting into wheel bosses, which must necessarily be tighter than the fitting of the same shafting into its bearings.

Slag Wool.—On blowing a jet of steam at about 50 lbs. pressure through fluid slag as it issues from a furnace, the slag is blown into fine fibers resembling asbestos or spun glass; from its appearance, the material thus formed is termed *slag wool*, also *silicate cotton* or *mineral wool*, and being non-combustible and non-conducting, is used as a covering for steam pipes, engine cylinders, etc.

Slaked Lime.—In masonry, lime which has undergone a chemical combination with water, thus losing solidity and cohesion.

Slate Roofing.—Slate, split and sawed into uniform rectangular slabs, about $\frac{3}{16}$ inch thick, and secured by means of nails to battens on a roof. The battens are generally underlaid with felt or waterproof paper board. The common size for a $\frac{1}{4}$ pitch roof is that known as Countess slates (20x10 ins.), the laps being usually 3 inches over the nail holes, which are generally drilled in the center, galvanized iron or brass composition nails being employed. If the nails are at the top or *head* of the slate, its *tail* must overlap the nail holes of the second slate below, thus giving in either case a *margin* or visible depth of $8\frac{1}{2}$ ins. for each course.

Sled.—In the conduit system of electric traction, a form of contact plow which, instead of being pushed along the conducting wire, is drawn over the wire after the car.

Sledge Hammer.—A heavy hammer wielded with both hands. That used by the blacksmith's helper is usually *cross pened*, and weighs from 5 to 14 pounds. The sledge used by a machinist or erector is usually double faced, as he uses it for driving work only. For light blows, the hammer man uses the sledge "*up hand*," for powerful blows it is wielded "*about sledge.*"

Sleeve Coupling.—1. A cylindrical piece bored to fit two lengths of shafting which it serves to unite, one length being keyed into either end.

2. A screwed pipe socket or socket coupling which joins lengths of screwed pipe together.

3. A cylindrical piece, forming two pipe bells placed back to back, used to connect the male ends of two cast iron pipes, where necessary.

Sleeve Joint.—A method of joining the ends of wires by inserting them into two parallel copper tubes soldered together, and twisting the whole by a special tool.

Sleeve of Plug.—A tube of brass encasing the forward end of a telephone switchboard plug for the purpose of making electrical contact with the barrel of a spring jack.

Slewing Gear.—An arrangement of parts for effecting a *slewing* motion in a crane, derrick, etc.; that is, swinging the jib from side to side on its pivot, so that it is brought fair with the hoist or the place of deposit. In hydraulic cranes, a pair of opposed cylinders, one on either side of the pivot, are employed to slew the jib through the required arc, thus obviating the use of guys and accurate centering is assured by means of regulable stops on the valve gear.

Slice Bar.—A thin, wide, iron tool, seven or eight feet long, for cleaning clinkers from the grate bars of a fire. The lower side of the slice bar should be flat so that it may slide on the surface of the grate bars, as it is forced beneath the fire; the upper portion of the edge should be in the shape of a half wedge, so as to crowd upwards the ashes and clinkers while the lower portion slides along.

Slide Resistance.—A form of rheostat employed in telegraphy in which the coils are arranged in a circle and controlled by a pair of contact arms, each capable of moving over a half circle of contact points.

Slide Switchboard.—A telephone switchboard employing slide contacts.

Slide Valve.—In a steam engine, a cup shaped piece of metal arranged to slide over and alternately cover and uncover the openings or ports through which steam is distributed to the cylinder; also called, *D valve* and *D slide*. It is situated in the steam chest, and is moved by the valve gear. This type of valve is satisfactory for use with low and medium steam pressures, but on account of being unbalanced, it is not used to advantage with the higher pressures. Accordingly, it is found on single cylinder engines, on the low pressure cylinder of compound engines, and sometimes on both the intermediate and low pressure cylinders of triple expansion engines. Engines using slide valves, can be constructed with less clearance than when fitted with piston valves; this is an advantage, but is offset by the perfect balance of the piston valve with respect to the steam features.

Slide Wire.—The wire of German silver or platinum alloy used in connection with a scale for the adjustable contact in a slide wire or meter bridge.

Slide Wire Bridge.—A form of Wheatstone's bridge in which a wire of German silver or platinum alloy is stretched over a graduated scale, the rest of the circuit including thick strips of copper having two gaps in which the known and unknown resistances are introduced. The galvanometer included in the circuit is connected with the wire by a sliding contact which is moved over the scale until a balance is reached and the galvanometer needle rests at zero; a *meter bridge* or *slide balance*.

Sliding Bed Plate.—A dynamo or motor bed plate which is movable within fixed limits for purposes of adjustment.

Sliding Contact.—1. An electrical contact obtained by a sliding motion of one conductor over another.

2. The contact which exists between two flat surfaces moved over each other, as differentiated from *rolling contact* in which one part rotates on the other.

Sliding Contact Key.—In a slide wire bridge, a spring key which, when depressed, causes a knife edge to make contact with the wire.

Sliding Friction.—In mechanics, the friction existing between two bodies in sliding contact with each other.

Sliding Joint.—A method of joining ends of metal parts, which are exposed to extreme changes of temperature, as for example, rails, steam-pipes, etc., so that a certain freedom of movement is allowed at the joint for expansion and contraction of the metal; also called *expansion* joint.

Sling.—An endless rope, by means of which objects are securely held while being raised or lowered, as with a crane or pulley block. Chains are frequently used for heavy lifts, having an eye at one end and a hook in the other, by which the sling is secured.

Slinging Wires.—1. Wire hooks, etc., upon which articles are slung within an electroplater's baths.

2. In pole line construction, running electric wires from pole to pole.

Slings.—In electroplating, looped pieces of insulated copper wire employed for suspending articles in the plating bath; also called *slinging wires*.

Slip.—1. That amount by which a mechanism falls short of its theoretical performance, with regard to something to which it is not rigidly connected, generally expressed as a percentage of the theoretical amount; as, the *slip* of an induction motor or of a pump.

2. In an induction motor, the difference between the actual speed of the rotor and synchronous speed. The speed of the rotor is lower than that of the revolving field, because the lines of force must cut the secondary conductors. This difference, called the *slip*, is measured in per cent of the speed of the revolving field which is known as the *synchronous speed*.

Slipmeter.—A device for determining the slip of an induction motor. There are three principal types; the *sectored disc*, employing a disc with white sectors mounted upon the motor shaft; the *vibrating reed* consisting of an alternating current electro magnet provided with a steel reed near one of its ends; and the *commutator* slipmeter in which a commutator, with as many segments as the motor has poles, is pressed against the end of the motor shaft.

Slip of Rotor.—In an induction motor, the difference in speed between the rotating field and the rotor conductors. It is usually expressed as a percentage of the speed of the field.

Slippage.—In an induction motor, the ratio between the speed of the rotor and synchronous speed.

Slipper Shoe.—A form of third rail contact shoe which extends at right angles from the shoe beam, permitting the use of a top guard over the third rail.

Slipping of Belt.—The failure of a belt to cling to its pulley and properly transmit its power.

Slip Rings.—In alternators, devices for conveying to the line the currents generated in the armature. They consist of brass or steel rings carried by the shaft and insulated from it, while copper or carbon brushes connected to the line bear upon them and make sliding contact; also called *collector rings*.

Slip Thimble.—In cable laying, an appliance for readily releasing a buoy from its connection with the ship.

Slope.—In a magnetic field, the direction in which the intensity of the field of force diminishes.

Slope of Potential.—The *drop of potential*, or the loss of pressure in an electric line due to the resistance of the conductor. When graphically represented this drop shows a sloping line. According to Ohm's law, the difference in potential between any two points within a circuit is equal to the product of the strength of the current, and the resistance of that portion of the circuit lying between those points. It may be stated in symbols as $E = I R$, in which E represents the loss in volts, I the current strength in amperes, and R the resistance in ohms.

Slots.—Grooves or channels sunk in the surface of an armature core for the reception of the windings.

Slot Space Factor.—In armature winding, the ratio of the sectional area of copper in an armature slot to the sectional area of the slot. It varies from 0.3 to 0.5.

Slotted Armature.—An armature having deep slots or channels in its core to receive the windings; an *iron clad armature*.

Slotted Conduit.—In the conduit system of electrical traction, a conduit for carrying the conducting wire, usually placed midway between the tracks and furnished with a continuous slot through which connection is made with the car motors.

Slot Wound Armature—A dynamo or motor armature in which the windings, instead of being laid on the surface, are imbedded in deep slots in the core; an *iron clad armature*.

Slow Burning Construction.—A type or class of construction suitable for mill buildings, in which heavy hardwood timbers are employed, fitting closely into each other, without crevices for the accumulation of dust, for the passage of air or for affording play to the flames of a fire. Experience has shown that such structures, while being far cheaper than fireproof buildings, resist the flames so much that little more than a superficial charring is likely to occur with ordinary fires.

Slow Speed Dynamo.—A dynamo designed to operate at low speed.

Slow Speed Motor.—An electric motor designed to operate at low speed.

Sludge.—1. In steam engineering, the muddy deposit which accumulates in a steam boiler.

2. In mining, the mud formed at the bottom of the drill hole, from the cuttings and water. When dug it is known as *boremeal.*

Sludge Cock.—In steam engineering, the cock at the bottom of a steam boiler which is employed for the purpose of cleaning the boiler from sludge by periodical *washing through* by a strong current of water. Usually called *blow off valve.*

Sluggish Magnet.—A magnet that is slow to acquire or part with magnetism.

Sluice Gate.—In hydraulic engineering, a sliding plate which covers the opening of a sluice, as in a dam, dock wall or lock gate. The gates or doors move in vertical channels and are actuated by a rack and pinion, or else by means of a long screw passing through a nut in the gate.

Smashing Point.—In incandescent lighting, the point reached when it becomes more economical to instal a new lamp than to continue burning a lamp which has passed its useful life. This point can be calculated when the rate at which the candle power falls off, and the watts per candle increase, and the cost of lamp and electrical energy are known.

Smee, Alfred.—Born 1818, died 1877. An English metallurgist and surgeon. He devoted much of his time to the study of electrical science and to chemistry, developing the primary battery known as the Smee cell. His researches in electro-metallurgy and electro-biology were of great importance, a noteworthy achievement being the art of electrotyping. He also published a number of valuable works on electrical, surgical and other scientific subjects.

Smee Cell.—A voltaic cell originally constructed by Smee in which the negative plate consists of a thin sheet of platinized silver, with an irregular surface tending to prevent the accumulation of hydrogen bubbles and hence retarding polarization. The platinised silver plate is usually attached to a wooden bar, and zinc plates, placed one on each side of it, are kept in position by a metallic cramp passing over the top of the bar. A binding screw, passed through the wooden bar is attached to the silver plate, and a similar binding screw, on the cramp that holds the zincs to the bar. An earthenware containing-vessel is required; the battery is excited by dilute sulphuric acid (7 volumes of water to one of acid). This cell is admirably adapted for electro-depositing and general galvanic experiments; but it is not suitable for producing electric light, or for intensity coils. It is easily managed, tolerably constant, and requires only one exciting fluid; therefore, a porous cell is dispensed with.

Smelting.—Separating metals from their ores by the heat of a furnace, accompanied by chemical action. To facilitate the latter, various *fluxes* are required and sometimes reducing agents.

Smelting, Electric.—The working of mineral ores by the use of the electric arc, in which the ore mixed with carbon is placed in a suitable furnace between carbon electrodes of large size, and fused by the arc produced by a current of intense strength.

Smoke Prevention.—In the combustion of fuels, a method whereby the smoke, which consists of finely divided particles of unconsumed carbon or pellicles of carbon containing hydrocarbon gases, may be exposed to the incandescent fuel together with a proper supply of air.

Smooth Body Dynamo.—A dynamo having a smooth core armature.

Smooth Core Armature.—A dynamo or motor armature having a smooth surface over which the winding is laid wholly outside, as distinguished from a slotted armature.

Snake.—In electric wiring, a long steel ribbon about $\frac{1}{8}$ in. wide and $\frac{1}{16}$ in. thick with a steel ball at one end, employed to *fish* wires through a conduit, the ball being pushed from one outlet to another.

Snapper.—1. In cable laying, an arrangement consisting of automatic metal jaws used at the end of a sounding line for the purpose of bringing up samples of the sea bottom.

2. In low tension or *make and break* ignition, a part of the igniter mechanism which causes the rapid separation of the electrodes to produce the *primary spark.*

Snap Switch.—A switch which makes or breaks a circuit by the action of a spring.

Sneak Current.—In a telephone circuit, a comparatively feeble current accidentally introduced through some fault in the line, which, though not strong enough to melt the safety fuse, may accumulate sufficient heat in time to seriously injure a bell or switchboard coil. It is arrested by a protective device known as a heat coil.

Sneak Current Arrester.—A device usually known as a *heat coil* which depends for its operation on the thermal effect of the current. The heat developed by the passage of a current though a coil of low conductivity melts the coil and the circuit is grounded. Heat coils are employed in telephone exchanges to protect the switchboard circuits against *sneak currents.*

S. N. Code.—In telegraphy, an abbreviation for single needle code.

Snifting Valve.—1. In a condensing steam engine, a back pressure valve on the exhaust, opening to the atmosphere to relieve any excess pressure, should the condenser flood; *a relief valve.*

2. On a locomotive, a relief valve fitted to the steam chest and constructed so as to admit air when the engine is running with closed throttle. This prevents the suction, created by the moving piston, drawing in air and cinders through the exhaust nozzle.

Snips.—Small, stout, short lipped shears, used especially for cutting sheet metal and wire.

Snow Sweeper, Electric.—A rotary snow sweeper driven by an electric motor.

S. N. Telegraphy.—Abbreviation for *single needle telegraphy.*

Soakage.—1. A term sometimes applied to the small charge of electricity which remains in a Leyden jar or other condenser after it has been discharged.

2. It is also used for the *residual magnetism* which is retained by a magnet after the magnetizing force has ceased to act upon it.

Soaking Out.—The gradual discharge which continues for some time after the first rush of escape when a conductor is grounded.

Soapstone.—Steatite, a massive variety of talc. It is often used for switch bases and switchboard panels not requiring finish, as it is superior to slate in insulating properties.

Socket.—1. A recess, or a piece furnished with a recess, into which some other piece may be inserted and securely held; as, a socket in the ground for the reception of a post or pole.

2. The receptacle into which the base of an incandescent lamp is fitted. The most common form is a cylindrical metal shell coarsely threaded so that an Edison base may be screwed into it making contact with the terminals at the top.

3. In a telephone switchboard; a *spring jack,* a deep socket provided with contacts into which a conducting plug may be inserted for interconnecting subscribers.

Socket Base.—The base of an incandescent lamp designed to fit into a socket in which contact is made with the terminals of the circuit. The base in common use is the *Edison* base. It has an outer shell provided with a coarse screw thread to which one end of the filament is connected, and a projecting central contact piece joined to the other end of the filament, the threaded part and the projecting center making the two contacts with the circuit when the base is screwed into the socket.

Socket Bolt.—A bolt passing through a thimble that is placed between the parts required to be connected by the bolt.

Socket Joint.—A means of connecting pipe together, where a collar or socket of larger size, having an internal or female thread, is screwed on the end of the one pipe, and the next length is screwed into it, thus making a heavy and substantial joint.

Socket Key.—A key or switch in the socket of an incandescent electric lamp by means of which the light is turned on or extinguished. It consists of a tap handle which carries a cam which works against a small brass disc, pressing it against a stud on the bottom of the lamp and releasing with a snap action.

Socket Lamp.—An incandescent electric lamp mounted upon a socket.

Soda, or Sodium.—One of the two principal alkaline metals, found nowhere uncombined, but most abundantly diffused as a compound; the chlorides present in sea water, and forming huge masses, as rock salt, the carbonates in extensive deposits, as the "alkali" of the plains. The chemical manufacture of carbonates, sulphates, and caustic soda is most important; as these compounds are used in immense quantities in glass manufacture, and processes too numerous to mention. There are two general processes of manufacture: (1) the Leblanc, in which common salt is treated with sixty per cent. sulphuric acid, resulting in sulphate and hydrochloric acid, which acid, the familiar spirits of salts, is condensed and used to form chlorine gas for bleaching powder. The sulphate is fused together with chalk or limestone and small coal, forming black ash, from which the carbonate is washed; (2) the Solvay or ammonia

process, in which strong brine is saturated with ammonia and then decomposed by carbon dioxide, forming carbonate of sodium and ammonium chloride or sal ammoniac, which is used in solution as an electrolyte for *primary cells*.

Soda Ash.—The trade term for sodium carbonate.

Sodium Carbonate.—White, crystalline, very soluble in water, forming an alkaline solution. In electroplating it serves as an addition to copper and brass baths, and the impure product is used to cleanse objects from grease.

Sodium Chloride.—Common salt, a compound of sodium and chlorine. It is found in a natural state as rock salt and is also obtained by evaporating brine. In *electroplating*, it is employed as a conducting salt for some gold baths, and for precipitating the silver as chloride from silver solutions. Besides its familiar use in the preparation and preservation of food, salt is employed in the derivation of sodium carbonate and caustic soda.

Sodium Hydrate, or Hydroxide.—Commercially known as *caustic soda*. It is prepared from the *tank liquor* of the Leblanc process, or from a sodium carbonate solution, by heating with *milk of lime*. Calcium carbonate separates out, a weak solution of caustic soda remaining; this is concentrated in iron pans until it has attained the desired consistency or strength, and is then cast in moulds. Caustic soda is used in electroplating for freeing objects from grease, it is largely employed in soap manufacture, the treatment of wood pulp in papermaking, the purification of petroleum, and the preparation of metallic sodium.

Soft and Hard Copper.—In electric wiring, ordinary pure copper is comparatively soft, and a span of any considerable weight cannot sustain its own weight. In a gale, the wind pressure greatly increases the stress upon the wire. Owing to refined methods of production, pure copper wire can now be obtained having a breaking strength of 28 to 30 tons per square inch. The higher tenacity is obtained by the molecular arrangement given to the particles during the process of drawing, and if the copper be really pure, the increase in resistance due to the hardening is of small amount.

Soft Brass.—In metals, brass which has been annealed after drawing and rolling; used for purposes requiring *ductility*.

Soft Brick.—This embraces those bricks not hard enough for outside walls, and includes *soft, salmon, backing up, pale, light, chimney, filling in, inside wall*, and *foundry brick*.

Soft Carbon.—A term sometimes applied to *amorphous carbon* as distinguished from graphite or diamond. Charcoal, lampblack and bone black are amorphous forms of carbon.

Soft Drawn Copper Wire.—Copper wire that has been annealed between the drawings, as distinguished from hard drawn copper wire.

Soft Iron.—A general term applied to both wrought iron and cast iron which can be shaped with ordinary cutting tools or abraded readily with files. The quality is due to the amount of carbon present and the manner of its combination, and also to the mode of crystallization. Iron which contains practically no carbon, as malleable iron, is very soft, so also is iron which contains the maximum of carbon, as foundry pigs, which may contain as much as 4 or 5 per cent. Carbon when present in the graphitical condition makes a soft iron, but a very much smaller proportion, when in the combined state, yields white iron, which is extremely hard. Iron allowed to cool slowly in sand is soft, while the same iron cooled rapidly against a metallic *chill* is hard. Soft iron is used for ordinary castings which have to be machined; tough, slippery and hard iron being reserved for special classes of work. Where it is necessary to machine castings of hard iron, grinding or cutting by means of an extremely slow feed is resorted to.

Soft Metal.—A term expressive of the density of the particular metal in relation to the purpose for which it is required. Metals are soft when they are more ductile, more elastic, and more easily cut, than the same metals when hard. Hard, brittle metals are rendered softer by annealing, by judicious cooling, and by chemical changes affecting the relative proportions of foreign metallic or non-metallic substances which are always present in variable quantities.

Soft Patch.—In boiler work, a patch or covering over a leak or defect which is fastened with bolts, in contradistinction to a hard patch, which is riveted.

Soft Porous Cup.—A porous vessel of soft baked earthenware for use in a two liquid voltaic cell to separate the electrolytes, while permitting chemical action to take place through its pores.

Soft Solder.—A solder fusible at comparatively low temperatures, as various alloys of lead, tin, and bismuth, which melt at from 200° to 500° Fahr.

Soft Steel.—A tenacious, bending, equal grained alloy of iron; low carbon steel.

Soft Woods.—In timber, the soft woods employed in carpenter work are *pine*, both yellow, red and white, *spruce*, *white wood*, etc.

Soil.—In plumbing, a composition of lamp-black and size, which is painted around parts to be soldered, to prevent the adhesion of the melted solder, except to its proper place, and thus give a neat and finished appearance.

Solar Telegraph.—The *heliograph*, an instrument for transmitting signals to distant points by means of a mirror adjusted to reflect the sun's rays in a series of flashes, in accordance with a prearranged code.

Solder.—A metal or metallic composition for uniting the surfaces of metals; a metallic cement. Common solders consist of equal parts of tin and lead; fine solder, 2 parts tin to 1 part lead; cheap solder 2 parts lead to 1 part tin. The fusing points of tin lead alloys are as follows:

TABLE:

Tin	1	to	lead	25..558°F.	Tin	1½	to	lead	1..334°F.
"	1	"	"	10..541°F.	"	2	"	"	1..340°F.
"	1	"	"	5..511°F.	"	3	"	"	1..356°F.
"	1	"	"	3..482°F.	"	4	"	"	1..365°F.
"	1	"	"	2..441°F.	"	5	"	"	1..378°F.
"	1	"	"	1..370°F.	"	6	"	"	1..381°F.

Solder Ear.—A trolley ear supporting a trolley wire by being soldered to it.

Soldered Rail Bond.—A rail bond consisting usually of thin strips of annealed copper bent into a V shape for greater flexibility, and soldered direct to some part of the rail by means of flat terminals which are made solid to provide good contact.

Soldering.—The act or process of forming joints upon or between metallic surfaces, by means of a fusible alloy or solder, whose melting point is lower than that of the metals sought to be united. After careful cleansing, a *flux* is applied to prevent oxidation while heated, a suitable quantity of solder is fused on the joint, by a heated copper bit or by the blow pipe flame, according as to whether soft or hard solder is employed. The soft solder easily follows the track of the iron, along the heated parts, by surface tension, but the hard solder requires more careful preparation and manipulation.

Soldering Bolt.—A copper bit, used when heated by tinsmiths and plumbers, to apply soft solder to a seam or joint.

Soldering, Electric.—1. The use of electric heat in melting solder.

2. Joining the ends of two conductors by electroplating their junction as they are held in contact.

Soldering Flux.—A material used to assist in the removal of oxides, etc., which form on metallic surfaces while heated, during the process of soldering, and assist the solder to run on the joints. *Resin* is used for electrical connections, and either it or a solution of *zinc chloride* is used for soft soldering; powdered *borax* is used with the blow pipe flame in hard soldering.

Soldering Furnace.—A small heating apparatus carried by plumbers and tin men for melting solder and heating their soldering tools.

Soldering Iron, Electric.—A soldering iron employing electric heat. The bolt of copper is surrounded by an insulated coil of wire which generates sufficient heat upon the passage of an electric current to heat the iron to a proper temperature.

Solenoid.—A spiral of conducting wire wound cylindrically so that, when an electric current passes through it, its turns are nearly equivalent to a succession of parallel circular circuits, and it acquires magnetic properties similiar to those of a bar magnet. The lines of force must be thought of as closed loops linked with the current. The conductor conveying the current passes through all the loops of force, and these are, so to speak, threaded or slung on the current line of flow. It will be readily inferred that since a solenoid of wire conveying a current attracts and repels by its extremities the poles of a magnet, two such spiral conductors conveying currents should attract and repel each other. This is found to be the case.

The lines of force form continuous closed curves running through the interior of the coil, and issuing from one end and entering into the other end of the coil.

A solenoid has north and south poles, and in fact possesses all the properties of an ordinary permanent magnet, with the important difference that the magnetism is entirely under control, for it is found that under all circumstances the strength of the magnetic field of a solenoid is at every point proportional to the strength of the electric current passing through its coils: if the current be increased, the magnetism is increased in proportion also; and if the current be stopped, all trace of magnetism disappears. The magnetic effect or the magnetising power of a solenoid is also proportional to the number of turns of wire composing the coil. At first, the presence of an iron core greatly increases the strength of the field; after a time, however, as the strength of the current flowing in the exciting coils is increased, the conductibility of the iron for the lines of force appears to decrease, until a point is eventually reached when the presence of the iron core appears to have no effect in increasing the strength of the field.

Solenoidal.—Relating to solenoids.

Solenoidal Blow Out.—A magnetic blow out employing a coreless solenoid as an electromagnet.

Solenoidal Distribution of Magnetism.—The distribution of lines of magnetic flux around and in a bar magnet, which, according to Ampere's theory, is identical with the flow of magnetizing force in a solenoid.

Solenoidal Magnet.—A bar magnet in which lines of magnetic flux are considered as flowing in the same manner as in the coils of a solenoid.

Solenoid Core.—A bar or rod of soft iron placed within the coils of a solenoid for the purpose of intensifying its magnetic properties.

Solenoid Galvanometer.—A galvanometer whose magnetic needle is acted upon by the coils of a solenoid which surround it.

Solid Angle.—The angle made by the intersection of three plane surfaces at one point.

Solid Back Transmitter.—A modern form of telephone transmitter so called because the back electrode is rigidly supported by the frame of the instrument. The front is very stiff, having the hard rubber mouthpiece screwed into it. The diaphragm of aluminum lies just back of the front with a rubber band snapped over it to provide an insulated cushion seat for the diaphragm. The two electrodes are carbon discs, the space between them being partially filled with carbon granules. The vibrations of the diaphragm are transmitted to the front electrode by a pin which makes a rigid connection between them.

Solid Carbons.—Carbons for arc lamps made of uniform density throughout, as distinguished from cored carbons.

Solid Conduit.—A conduit for underground wiring in which the conductors are permanently embedded in insulating material, preventing their removal.

Solid Depolarizer.—The use of a solid, such as the platinum on the silver electrode of a Smee cell, as a mechanical means of reducing polarization in a primary cell.

Solid Earth.—A term sometimes used for *dead earth*, a fault in an electric circuit due to the complete grounding of the line.

Solid Thermostat.—A thermostat which closes an electric circuit by the expansion of a solid body under excessive heat.

Solid Wire.—An electric conductor consisting of a single cylindrical wire.

Solubility.—The property or capacity of being dissolved; as, by an acid, by water, etc.; capability of being taken up as a solution.

Soluble Electrodes.—In electroplating, metal electrodes which are dissolved by the electric current for the purpose of depositing the metal upon articles to be plated.

Soluble Glass.—A thick, syrupy liquid made by melting together sodium carbonate and siliceous sand. It may be mixed with water, and if painted over a wall is decomposed by the action of the carbon dioxide in the air, a film of silica or silicate being left, forming a hard protective surface or enamel on the wall. Also known as *water glass*.

Solution.—The action of an attraction between one or more solids and a fluid when brought in contact, by which the former become themselves fluid, and are diffused through the latter without change or loss of properties; the state of a body as thus diffused. When this attraction is completely satisfied so that no more of the solid will be dissolved, the fluid is said to be *saturated*.

Solvent.—In chemistry, a liquid in which a substance is dissolved to make a solution; thus, water is the solvent for acids.

Sonometer.—An apparatus for studying the relation between the length of musical strings and the pitch. It consists essentially of a sounding box carrying a graduated scale over which a string is stretched between two fixed bridges, and over a movable bridge which may be set at any desired length.

Sonorescence.—A property exhibited by hard rubber and certain other substances, of emitting sound when acted upon intermittently by radiant heat or light.

Sonorous.—Producing sound when struck; *resonant*.

Soot.—A black substance formed by combustion, or disengaged from fuel in the process of combustion, rising in fine particles,

and adhering to the sides of the chimney or pipe conveying the smoke; strictly, the fine powder, consisting chiefly of carbon, that colors smoke, and which is the result of imperfect combustion.

Soot Cell.—A carbon cell employed in connection with a radiophone.

Sound.—The sensation produced on the mind by the impact upon the ear of sound waves transmitted through the air by the vibrations of a sounding body.

Sounder.—In telegraphy, an instrument consisting essentially of an electromagnet with an armature moving between stops, thereby making two distinct sounds representing the dot and dash of the Morse code, by which the operator can read a message by ear.

Sound Error.—In telegraphy, an error made by an operator in reading a message by sound.

Sounding Doard.—In a stringed musical instrument as a violin or cello, a resonant wooden box that vibrates in unison with the string and intensifies the sound; also called *sounding box*.

Sounding Tube.—A tube attached to the end of a sounding line by means of which samples of the sea bottom may be brought to the surface.

Sound Waves.—Waves of vibrating air particles transmitted through the air by the vibrations of a sounding body.

Source, Electric.—Any appliance for generating an electromotive force.

Sources of Energy.—On the earth's surface, the principal sources of energy are: (1) muscular energy of man and animals, (2) the wind, (3) flowing water, and (4) fuel. These sources are made possible by the rays of the sun, as under its influence vegetation grows and wood is formed. When fuel is burned under a steam boiler three tenths of its heat energy escapes in the chimney and by radiation: seven tenths appears as potential energy in the steam. Of this seven tenths, six parts are spent in heating the condensing water and the remaining one tenth of the original heat energy of the wood is converted into mechanical work by the steam engine. All the potential heat energy of the fuel is, after various transformations, converted into heat, which mingles with the store of heat in the atmosphere. Though apparently lost, it is not destroyed.

Southern Lights.—The *aurora australis*, the counterpart of the northern lights or aurora borealis, seen in the southern hemisphere in the direction of the south magnetic pole. It exhibits the same characteristics as the northern aurora, showing broad flashes or ribbons of waving light which are undoubtedly due to electrical causes.

South Magnetism.—The magnetism of the south pole of a magnet which tends to point toward the earth's south magnetic pole. The magnetism of the south seeking pole as distinguished from that of the north seeking pole.

South Pole of Magnet.—That pole of a magnet or magnetic needle which tends to point to the south; also called the austral, blue, negative, south seeking pole or unmarked end.

South Seeking Pole of Magnet.—The south pole of a magnet.

S. P.—Abbreviation for *single pole.*

Spaco Factor.—In armature winding, the ratio of the sectional area of the copper in an armature slot to the sectional area of the slot. It varies from 0.3 to 0.5.

Spacer.—In double current telegraphy, an electromagnetic device for sending reverse currents into the line.

Space Telegraphy.—A term sometimes used for *wireless telegraphy.*

Spacing Battery.—In the double current system of telegraphy, a battery for sending spacing currents.

Spacing Current.—1. In double current telegraphy, a current used in connection with a polarized relay in the reverse direction to the "marking" current to restore the tongue of the relay to the spacing side.

2. In automatic telegraphy, a current opposite in direction to the "marking" current so that spaces are left in the recorded message between the dots and dashes.

Span Cable Way.—In a telpher system, a tightly drawn overhead cable for supporting the car and conveying power to its motor.

Span Dogs.—A pair of timber dogs linked together at one end by means of a ring.

The dogs span or straddle the log, the fangs are driven into the wood on either side, thus grappling it for hauling or hoisting.

Span Guard Wire.—In a trolley system, a guard wire stretched across the street above the span wire, at right angles to the running guard wire, to further protect the line from the danger of falling wires.

Spanish Spoon.—In pole line construction, a long handled shallow ladle-shaped shovel for digging post holes; *a spoon shovel.*

Span Wire Hangers.—Trolley hangers by means of which the trolley wire is attached to the span wires.

Span Wires.—In a trolley system, wires stretched across the street from side poles for supporting the trolley wire.

Span Wire Suspension.—In a trolley system, a method of suspending the trolley wire over the center of the tracks by means of steel span wires, stretched across the street from side posts set along the curb.

"Spare" Machine.—An extra machine, as a dynamo or motor held in reserve in an electric plant, so as to be available in case of accident in the installation.

Spare Parts.—The supply of duplicate portions of machinery together with the order to which they belong, consisting of those which wear out rapidly and therefore require frequent replacement, or those vital parts upon which the efficiency of the machine or engine mainly depends, and which, in the case of a break down, it would be difficult or impossible to replace immediately.

Spark.—In mechanics, a small particle of fire or ignited substance which is emitted from bodies in combustion.

Spark Advance.—In an internal combustion engine, an advance given to the spark ignition to ensure complete combustion at the beginning of the power stroke.

Spark Arrester.—Wire netting used to screen the carbons of arc lamps to prevent the scattering of sparks from the arc.

Spark Chronograph.—A form of chronograph in which a continuous tracing made by a stylus is interrupted, at the beginning and end of the event to be measured, by minute perforations made by electric sparks from a Ruhmkorff coil.

Spark Coil.—1. A familiar name for the *induction coil* employed to create oscillations in wireless telegraphy, to provide ignition in automobiles, and for other purposes in telephone and medical work. It consists essentially of a core composed of a bundle of soft iron wires surrounded by two separate windings, a *primary* made up of a comparatively few turns of coarse wire, and a *secondary* composed of very many turns of finer wire, the two coils being insulated from each other. The primary coil is connected to the battery through a contact breaker which magnetises and demagnetises the core at a rate governed by a spring. The lines of force so created cut the secondary and set up in it an induced electromotive force which may be made great enough to cause sparks of considerable length to jump between the electrodes of a spark gap.

2. In a system of electric gas lighting, a coil of many turns of insulated wire wound about an iron core for the purpose of intensifying the spark on breaking the circuit.

Spark Condenser.—In spectroscopy, a form of spark gap having its terminals fused into a glass vessel containing the medium whose spark spectrum is to be observed.

Spark Discharge.—A disruptive electric discharge which takes place between two electrodes across a dielectric, accompanied by a spark.

Spark, Electric.—The luminous manifestation exhibited in a spark discharge.

Spark Gap.—1. The space between two electrodes brought to a difference of potential, filled with the dielectric through which the spark discharge takes place.

2. The distance between the two metallic points in a spark plug. The amount of opening varies from about $\frac{1}{32}$ in. to $\frac{1}{16}$ in.

Spark Gauge.—A spark gap in air so constructed that the distance between the sparking points can be accurately determined.

Sparking.—Giving off sparks at the contacts between the brushes and the commutator of a dynamo armature due to bad adjustment or bad condition of the parts, and resulting in serious injury to the machine if allowed to continue; *flashing.*

Sparking Circuit.—The electrical wiring of a gasoline engine or of a motor car con-

necting the dynamos, accumulators, induction coils and sparking devices whereby ignition of the charge is effected.

Sparking Coil.—An induction coil as used with an internal combustion engine; also called *spark coil, induction coil*, etc.

Sparking Discharge.—A spark discharge.

Sparking Distance.—The length of the spark gap through a dielectric across which a spark discharge takes place; the *striking distance.*

Sparking Terminals.—The terminals or electrodes separated by a spark gap.

Sparkless Commutation.—Operating a dynamo without sparking at the commutator brushes; *quiet commutation.*

Spark Micrometer.—1. An electric resonator having a spark gap which may be delicately adjusted by a micrometer screw.
2 A spark gap adjustable by a micrometer screw for the purpose of measuring the length of an electric spark.

Spark Plug.—A plug of some non-conducting material, such as lava, screwed into the wall or head of a gas engine or motor cylinder; it holds and insulates the two German silver or platinum-iridium points between which the igniting electric spark leaps.

Spark Regulator.—A device for controlling the spark advance. Many gas and gasoline engines effect their governing by regulating the timing of the spark, advancing it as more power is required, retarding it as the demand for power decreases; called *timer*, also *distributer* in synchronous ignition. The latter term is frequently used erroneously for the contact maker of a magneto.

Spark Tube.—A tube used to test the degree of exhaustion reached in the vacuum of an incandescent lamp bulb. When, upon being connected with an induction coil, a spark ceases to pass within the tube, the vacuum is considered satisfactory.

Spasmodic Governor.—A governing device for electric motors which regulates the current applied in proportion to the work required.

Spawl.—A splinter or fragment, as of wood or stone.

S. P. Cut Out.—Abbreviation for *single pole cut out.*

Speaking Galvanometer.—A mirror galvanometer for receiving signals over a submarine cable.

Speaking Key.—A telegraph key used in transmitting signals.

Speaking Mirror Plug.—A plug for a cable telegraph mirror galvanometer provided with a suspended mirror and magnet.

Speaking Switch.—In telegraphy, a signal or sending switch.

Speaking Tube Mouth Piece Alarm.—An electric bell that is rung at the distant end of a speaking tube by the movement of the metal plate in the mouth piece at the calling end.

Speaking Tube Telephone System.—A name sometimes given to a house telephone system making its various connections without the use of a central switchboard.

Speaking Wire.—In a telephone system, a wire for communicating between two exchanges, as distinguished from the subscribers' wires.

Specification.—In erecting, a statement of particulars; a document setting forth the various requirements, conditions, and stipulations with regard to dimensions, quality of material, class of workmanship, tests or trial performance, of anything about to be manufactured or built; such a schedule of particulars is usually furnished to would be contractors or furnishers, by the person or corporation desirous of being supplied, or by the technical advisers of the latter.

Specific Conductance or Conductivity.—A standard of reference for comparing the conductances of different substances. It is the conductance between the opposite faces of a unit cube of a substance in mhos; being the reciprocal of specific resistance or resistivity.

Specific Gravity.—The weight of a given substance relatively to an equal *bulk* of some other substance which is taken as a standard of comparison. Water is the standard for liquids and solids, air or hydrogen for gases If a certain mass be weighed first in air then in water, and the weight in air divided by the loss of weight in water, the result

will give the specific gravity; thus, taking a ten pound piece of cast iron, its weight, suspended from the scale-pan in a bucket of water, will be 8.6 lbs., dividing 10 by the difference 10—8.6 or 1.4, the answer will be 7.14, which is the specific gravity of cast iron.

Specific Heat.—The amount of heat required to raise the temperature of a substance a unit amount, as from 0° to 1° of the thermometer scale, as compared with water under the same conditions, taken as a standard. Thus, the same quantity of heat which will raise one pound of water 1° Fahr., will raise about 4½ pounds of cast iron 1° Fahr., so, the specific heat of water being taken as 1, that of cast iron is 0.241.

Specific Hysteretic Dissipation.—The hysteresis loss experienced by any substance *per unit of volume.*

Specific Inductive Capacity.—The ratio between the capacity of a condenser employing a certain substance as dielectric to the capacity of a condenser of equal size with an air dielectric taken as a standard; the *dielectric co-efficient* or *constant.* Also called *specific capacity* and *specific dielectric capacity.*

Specific Magnetic Capacity or Conductivity.—The ratio of the magnetic flux density of a magnet to the magnetizing force acting upon it. It is the relative conducting power for lines of force and hence the reciprocal of reluctivity or specific magnetic reluctance. Also called *permeability.*

Specific Magnetic Reluctance or Resistance.—The reluctance per unit of length and unit cross section that a material offers to being magnetized. It is usually taken as the reluctance of one centimeter cube of the magnetic path. Also called *reluctivity.*

Specific Molecular Conductivity.—The molecular conductivity of an electrolyte taken in comparison with that of a substance adopted as a *standard.*

Specific Reluctance.—The same as specific magnetic reluctance; *reluctivity.*

Specific Resistance.—The resistance in ohms of unit length of a substance having unit cross sectional area, and at a given temperature; *resistivity.*

Specific Volume.—In physics, the volume of a gas or vapor compared with that of the liquid from which it is generated.

Spectrograph.—An instrument for photographing a spectrum, consisting of a spectroscope in which a photographic plate is introduced instead of an eye piece, in the focal plane of the telescope objective.

Spectrometer.—A spectroscope provided with a graduated circle for measuring the duration of the light in passing through the prism.

Spectro-photometer.—An instrument by means of which the spectra of two light sources are caused to be placed one above the other for the purpose of making a comparison of their color bands.

Spectro-photometry.—The science and practice of using the spectro-photometer in measuring and comparing the intensities of the colors of different spectra.

Spectroscope.—An instrument whereby a spectrum is produced from any source of light, in order that it may be examined. The rays of light are formed into a parallel beam, by means of a *collimator*, which is a tube with an adjustable *slit* presented towards the light, and a *lens* at or near the other end. As the light issues from the lens, it falls upon a *prism*, by means of which the parallel beam is split up into a spectrum. This latter is viewed through an adjustable telescope, the position of the various lines and bands being ascertained by means of crosswires, scales and verniers.

Spectrum.—An image or brilliantly colored band thrown on a screen by the refraction of a beam of light through a prism. The colors merge into one another, but form seven easily distinguishable groups: red, orange, yellow, green, blue, indigo, violet; each color being produced by a different wave length of the ray, and the grouping due to the varying deviation through the prism, which is greatest with the violet and least in the red. The rainbow furnishes a familiar instance of the solar spectrum, the rays of sunlight being decomposed and refracted by the falling rain drops.

Spectrum Analysis.—When any element is burned it gives a characteristic flame, and examination of that flame by means of the spectroscope shows that each element will give its own spectrum, composed of wave lengths peculiar to itself.

Speed Direction Indicator.—An indicator employed on a steamship to show the speed at which the propeller shaft rotates, and the direction of its motion.

Speed Gear.—In an automobile, the change speed gear, whereby the speed ratio

of the engine and rear wheels of the car is changed according to the gradient or running conditions.

Speed Indicator.—1. A device for showing the rate of speed at which a vehicle is proceeding, either by: (1) the height of a liquid column in a glass tube, the oil or water being forced up by means of a rotary pump driven by the axle of the vehicle; (2) the height to which a small centrifugal governor will rise in the same circumstances, the sleeve pulling a needle around a graduated dial. The same as *tachometer*, the latter usually indicating revolutions and not distance.

2. A portable counter for revolutions. The observer thrusts the point of the spindle of the instrument into the center left in the end of the revolving shaft, and the revolutions are registered by a train of gearing. By noting the figures at the beginning and end of a stated period, the rate of revolutions per minute is easily computed. Some speed indicators are arranged with adjustable pointers which may be brought to zero, thus reading directly the number of revolutions.

Speeding of Dynamo.—Adjusting the speed of a dynamo to the requirements of its external circuit.

Speed of Ignition.—This has reference to the rapidity with which chemical combination takes place between the air and gas in a gas engine. The speed of ignition varies with the compression, temperature, and quality of the mixture. The speed of ignition must always exceed the piston speed in order to obtain the best results.

Speed of Rotation.—The number of revolutions per unit of time performed by a rotating body.

Spelter.—1. A commercial name for zinc in the impure state in which it is shipped from the mines.

2. An alloy of copper and zinc, mixed together in various proportions, of needle-like or granular form. This is used in brazing, and is the same as *hard solder*.

Spent Acid.—An acid solution that has become exhausted so that it is no longer capable of performing chemical action.

Spent Liquor.—The liquid of a plating bath out of which so much of the dissolved metal has been deposited as to render it no longer effective for electroplating.

Spermaceti Candle.—A candle made from spermaceti, a white waxy substance obtained from the head of the sperm whale, and prepared by chilling and expressing. The commercial candle contains an admixture of wax. It is the standard candle for establishing *candle power*, the British unit of illumination. One candle power is the light of a sperm candle consuming 120 grains per hour.

Spewing of Cable Core.—A break in a submarine cable such that the core protrudes through the sheathing.

Sp. Gr.—An abbreviation for *specific gravity*.

Spherical Aberration.—A want of sharpness in images seen through lenses or reflected from spherical mirrors having an aperture of excessive length.

Spherical Armature.—A dynamo armature having its coils wound upon a spherical core, and designed to revolve in a circular chamber between the pole pieces.

Spherical Bougie Decimale.—A unit of light flux equivalent to the light of a *bougie decimale*, emitted by a luminous source in all directions.

Spherical Candle Power.—The candle power of a light source measured in every direction, as if illuminating the inner surface of a sphere surrounding the lamp.

Spherical Reduction Factor.—The spherical reduction factor of a lamp equals the mean spherical candle power divided by the mean horizontal candle power.

Spherometer.—An instrument for measuring the curvature of a *spherical surface*.

Sphygmogram.—A tracing made by the pulse with the use of a sphygmograph showing the characteristics of the beating of the heart; a *pulse tracing*.

Sphygmograph.—An electrical instrument for graphically recording the beating of the pulse in order to determine the condition of the heart. Also called a *sphygmoscope*.

Sphygmophone.—An electrical instrument including a microphone for examining the condition of the pulse.

Spider.—An arrangement consisting of three or four radially projecting arms by means of which the core of a dynamo or motor armature is sometimes mounted upon its shaft.

Spider Arm.—One of the radial arms sometimes used for fastening a dynamo or motor armature to its shaft.

Spike.—A very large nail:
12d spikes are 3¼ inches long, 45 to the pound.
16d spikes are 3½ inches long, 28 to the pound.
20d spikes are 4 inches long, 20 to the pound.
30d spikes are 4½ inches long, 16 to the pound.
Railway spikes are larger and of various patterns.

Spinning Metal.—The process of forming circular articles, many of which are used for electrical purposes, from soft ductile sheet metal by pressure on the circumference while they are revolving in a lathe. A wooden chuck or mould of the interior surface is attached to the fast headstock, while the sheet of metal is pinched between the chuck and the loose headstock. As mould and metal revolve, pressure is applied to the latter, by means of various tools and burnishers, which cause the metal to conform to the shape of the mould. The latter is often made up of concentric pieces fitting into one another, which may be drawn out one by one, as required by the progress of the manufacture.

S Pipe.—In pipe fittings, a pipe whose outline is roughly that of the letter *S*, used for connecting parallel lengths of straight piping. Also called *offset elbow.*

Spiral.—In electric practice, a conducting coil of wire. Strictly speaking a spiral is coiled in one plane like a watch spring, but the word is often used to apply to a *helix* which is a coil elongated as if wound along the surface of a cylinder or cone.

Spiral Storage Cell.—An early type of accumulator consisting of two lead sheets rolled up together without contact, immersed in a dilute solution of sulphuric acid.

Spiral Winding.—A method of winding resembling a solenoid employed on a ring armature.

Spirit Compass.—A very sensitive form of mariner's compass in which the bowl is filled with alcohol upon which the compass card floats, thereby greatly lessening the friction and vibration.

Spirit Level.—One in which the adjustment to the horizon depends on the position of a bubble, or small vacant space, in the upper side of a glass tube, which is slightly curved and nearly filled with alcohol or ether.

Spirits of Salt.—A commercial name for hydrochloric or muriatic acid.

Splash Lubrication.—A system of lubrication, especially employed in single acting engines, the moving portions being enclosed in a tight casing filled with oil to the level of the shaft. The cranks dip into the oil at each revolution and splash the lubricant over the moving parts and also the cylinder walls, where no cover and stuffing box is fitted. Openings are made in the middle of the crankpin and crosshead brasses, so that the oil has free access to them; this system is sometimes used for engine lubrication on *direct connected generating sets.*

Splayed Joint.—A method of jointing a covered stranded cable, in which the covering is removed a short distance from each end, the separate wires opened out, the two sets brought end to end and laced together, and the whole secured with solder.

Splice.—1. To unite, as two ropes or parts of a rope, or as one to another, by a particular manner of interweaving the strands; the union being either between two ends, or between an end and the body of a rope; to unite by lapping two ends together and binding, or in any way making fast.

2. To connect; as, pieces of wood or metal, such as beams or railway bars, by means of overlapping parts bolted together, or so shaped as to hold themselves in continuity; to scarf.

Splice Bar.—A name sometimes given to a fish plate for joining the ends of two rails, as in electric railways.

Splice Box.—In a system of underground wiring, a box containing the cable splices so situated as to be readily accessible for repairs or further connections.

Splicing.—Joining two lengths of cable by cutting away the lead sheath at each end, laying bare the separate wires, twisting together and soldering the corresponding pairs, renewing the insulation throughout and covering the whole with a lead sleeve.

Splicing Ear.—A trolley ear designed to join two lengths of a trolley wire.

Splicing Mallet.—A mallet for laying on the serving to protect the splice of a cable; a *serving* mallet.

Splicing Sleeve.—A lead sleeve drawn over a cable splice and wiped to the sheath at each end, completing the splice.

Splicing Tube.—A tube of conducting material used to complete a joint in an electric conductor.

Splicing Wrench.—A tool employed in finishing a cable splice, to force the wires of the sheath into their proper twist.

Split Battery.—A series connected battery with its central portion grounded.

Split Current.—A current flowing in a divided circuit.

Split Dynamometer.—A dynamometer used in testing transformers, and provided with two coils, one carrying the primary and the other the secondary current, so that its readings are proportional to the mean value of the product of the currents.

Split Lead Tee.—A lead sleeve resembling the letter T, and split throughout its length so that it may be readily applied to a cable at a point where a branch is joined to it.

Split Phase.—A single phase alternating current divided into polyphase currents by a phase splitting device.

Split Phase Motor.—A single phase induction motor provided with a phase splitting device for starting it.

Split Plug.—A form of contact plug provided with two insulated contact sleeves.

Split-pole Converter.—A rotary converter designed to permit varying at will the ratio of the d. c. voltage to the a. c. voltage by the variation of field excitation only. The change of flux is accomplished by splitting each pole into sections along axial planes. The sections are subjected to different magnetomotive forces which may be varied, by hand or automatically, during operation.

Split Pulley.—A belt pulley, made in two halves joined to each other by bolts, for convenience in fixing on shafting already in position.

Split Ring Magnet.—A ring shaped magnet core with an opening or split throughout its length.

Split Secondary.—A secondary of an induction coil made up of two sections.

Spluttering Arc.—A voltaic arc producing a spluttering noise because of defective carbons.

Spoil Bank.—In civil engineering, a bank formed by the earth taken from an excavation, as from a trench.

Sponge Electrode.—In electro-therapeutics, a form of electrode for applying electricity to the body through a sponge.

Sponge Lead.—The active material employed for the negative plate of a storage battery. It gives the plate a grayish color which makes it easy to distinguish from the reddish brown positive plate. It is pure lead which has been reduced to a spongy state by the passage of the charging current.

Spongy.—1. Having a cellular structure, similar to sponge.

2. In metallurgy, a defective or honeycomb like state of cast metals, due to gases which cause blow holes, or cavities in the metal.

Spontaneous Combustion.—A term which is applied when anything catches fire without the application of an external agent. When any mass of matter is slowly oxidizing and the heat generated is unable to escape, the temperature rises. The rate of oxidization proceeds with greater rapidity until the mass bursts into flame; oily waste and slack coal containing sulphur are very liable to spontaneous combustion.

Spontaneous Electricity.—A term sometimes applied to the electricity derived from the melting of sulphur.

Spoon Shovel.—A long handled shovel shaped like a round blunt spoon, useful in digging holes for the erection of poles for overhead wires; a *Spanish spoon.*

Spot.—In a mirror galvanometer, a spot of light reflected by the mirror upon the scale.

Spotted Filament.—An incandescent lamp filament which, owing to defective construction, shows spots of unequal light.

Sprague, Frank Julian.—Born 1857. An American electrical engineer, inventor of the constant speed electric motor (1884), the multiple unit system of electrical train operation (1887); pioneer of the modern trolley road, the first of which he installed in Richmond, Va. (1887-8); and designer of high speed electric elevators.

Spray Arrester.—A glass plate placed on the top of a storage cell, and running back

into the solution to prevent the spray of acid vapor, caused by the bursting of bubbles on the surface of the solution, from pervading the air of the room, when the solution, having reached a fully charged condition, begins to "*boil.*"

Spray Pipe.—The perforated pipe admitting the cooling water within a jet condenser; sometimes termed the *rose.*

Spread of Windings.—The *pitch* or spacing of armature coils. It may be defined as the number of elements of the winding which must be passed through in forming a loop.

Sprengel Pump.—A device for attaining a very high vacuum, such as is necessary in the manufacture of incandescent electric lamps. Mercury is fed into a funnel at one extremity of a long *U* tube, this tube having a return bend with a longer drop leg on its other end; a nozzle situated within an annular enlargement, at the top of the drop leg, breaks the flow of the mercury into a series of slugs with air between them. Each slug, falling down the drop leg, acts as a sort of piston, sucking the air behind it, and, as a connection on the return bend communicates with the vessel to be exhausted, the latter is speedily emptied of air. The U tubes being over barometric height, air cannot pass up them even should the pump stop. Escaping mercury from the drop leg or "fall tube" collects in a vessel which surrounds its base.

Spring Ammeter.—An ammeter in which the current to be measured moves the needle against the action of a spring.

Spring Clips.—Metal jaws provided with a spring so as to make firm contact with the blades of a knife switch when closed.

Spring Contact.—An electrical contact that is actuated by a spring.

Spring Dynamometer.—A form of dynamometer employing an ordinary spring balance to measure the strength of a force.

Spring Jack.—A device, employed especially in telephone switchboards, by means of which, when a plug is introduced into a socket, suitable contact springs engage the plug contacts and complete the connection with the circuit.

Spring Jack Cut Out.—A cut out constructed like a spring jack, so that a circuit may be closed by the insertion of an insulating plug or wedge between the spring contacts of the jack.

Spring Jack Switchboard.—A telephone switchboard provided with spring jacks for every subscriber's line, with which connections are made by the insertion of calling plugs.

Spring Manometer.—A manometer for measuring the pressure of gases by the movement of an index against the action of a spring.

Spring Motor Suspension.—A method of suspending a street railway motor by springs carried on the truck.

Spring Relay Contact.—A relay contact which is broken by the release of a spring as soon as the current is cut off.

Spring Voltmeter.—A voltmeter which measures electric pressure by the turning of an index against the action of a spring.

Sprocket.—In chain or link belting, a wheel with teeth around its circumference, shaped so that they may fit into the links of a chain which the sprocket drives, or by which it is rotated.

Sprocket Chain.—A chain for transmission of power, whose links have openings to receive the teeth of a sprocket wheel.

Spurious Resistance.—The resistance in an electric circuit due to the pressure of a counter electromotive force, as distinguished from the true or ohmic resistance of the circuit.

Square Mil.—A unit of area equal to .000001 of a square inch, used especially in the measurement of the cross section of wires.

Square Wire.—A wire having a square cross section, sometimes used in winding armatures.

Squeeze.—In electroplating, an impression or mould made in wax or paper pulp by pressing it hard against the type when set up ready for printing.

Squirrel Cage Winding.—A form of armature winding much used in rotors of induction motors. The conductors consist of copper bars lying in longitudinal slots near the surface of the core, the bars being connected to a short circuiting ring of copper at each end. The name for this form of winding is suggested by the resemblance of the finished armature to the wheel of a squirrel cage.

Squirted Filament.—An incandescent lamp filament composed of a thread formed by squirting a solution of cellulose through a small nozzle and hardening it in water.

S. R. G.—Abbreviation for *standard railroad gauge, viz.:* 4 feet, 8½ inches.

Stable Galvanization.—In electro-therapeutics, the process of applying the electric current to the body of a patient by means of two fixed electrodes; as distinguished from *labile* galvanization in which one of the electrodes is moved about.

Stable Equilibrium.—The state of a body when its position is such that it is necessary to do work upon it in order to displace it.

Stage Regulator.—A form of switch for controlling the incandescent foot lights upon the stage of a theatre.

Staggered Armature.—A term sometimes applied to an armature whose windings are laid on diagonally.

Staggering.—An arrangement of commutator brushes such that one brush rests upon the commutator surface slightly in advance of the other, so as to bridge over a break in the circuit of the armature wires.

Staging.—1. In building, a temporary support of posts and boards, or a platform slung up with ropes, etc. It is less strong than a scaffolding.

2. In civil engineering, a stout and substantial arrangement of platforms, decking, etc., supported by heavy timbers or balks. The parts are usually connected by *dogs*, to save spoiling the timber by bolt holes, which would render it unsalable upon dismantling.

Staking Out.—The operation of setting out boundaries, lines, etc., by means of stakes driven in the ground, generally with cords stretched from one stake to another; the process of marking out the lines for the foundations of a structure, by means of cords stretched over stakes or batten boards which are carefully placed at each angle of the proposed excavation.

Stalk of Insulator.—The pin upon which a line wire insulator is screwed.

Standard.—A support erected upon the roof of a building for carrying telegraph or other wires.

Standard Candle.—A sperm candle ⅞ in. in diameter and made to burn 120 grains per hour, adopted as a standard source of light, from which the British unit of illumination, the candle power, is derived.

Standard Cell.—A special form of primary cell used to establish the normal value of the volt. The Clark cell was for a long time universally used as the standard with an E. M. F. of 1.434 volt at 15 degrees C. An improvement known as the Carhart-Clark cell had an E. M. F. of 1.44 volt. The cell now recognized as the standard is the *Weston cadmium cell* containing electrodes of cadmium amalgam covered with a layer of cadmium sulphate crystals, and pure mercury in contact with a paste of mercurous sulphate, cadmium sulphate crystals and metallic mercury; the electrolyte being concentrated solution of cadmium sulphate and mercurous sulphate. The Weston cell has an E. M. F. of 1.0186 volt between 5° and 26° C. Its chief advantages over the Clark cell are its much lower temperature coefficient and longer life.

Standard Clock.—An accurately regulated clock by which other time pieces may be set.

Standard Coil.—A standard *resistance coil.*

Standard Compass.—A mariner's compass adopted as a standard for the comparison of other compasses.

Standard Copper.—Matthiessen's standard of conductivity is the commercial standard. It is a copper wire with the following properties at a temperature of 0° C.; specific gravity 8.89; length 1 meter; weight 1 gram; resistance .141729 ohms; specific resistance 1.594 microhms per cu. cm.; relative conductivity 100%.

Standard Cross Arms.—Cross arms for telegraph poles made in all particulars according to specifications.

Standard Feeder.—A feeder having standard voltage, *i. e.*, whose pressure is from 110 to 220 volts.

Standard Illuminating Power.—Any light source adopted as a standard for photometrical measurements, such as the carcel, violle, British candle, bougie decimale, carcel lamp, pentane standard, etc.

Standard Instrument.—In electrical measurement, a good ammeter or voltmeter employed as a standard for the purpose of calibrating other instruments. They are themselves checked at intervals by primary standards known as standard cells, representing the normal value of a volt.

Standardization.—The act of selecting the most suitable dimensions or proportions for structural or mechanical parts, thus obtaining uniformity of practice.

Standardized Cell.—A voltaic cell generating a known electromotive force of constant value which has been determined by comparison with a standard cell.

Standardized Resistance Coil.—A resistance coil having a known resistance that has been compared with a standard and verified.

Standard Megohm.—The megohm employed as a standard in measuring electrical resistance.

Standard Ohm.—A standard of resistance equal to that offered by a column of pure mercury 106.3 centimeters in length, of uniform cross section, and weighing 14.4521 grams at a temperature of 0° C.

Standard Quadrant.—The length of a quadrant of the *earth's meridian* taken through Paris, being 10^9 centimeters long.

Standard Resistance.—A resistance, as that of the standard ohm, adopted as a standard for electrical measurement.

Standard Resistance Coil.—A coil having a known resistance employed for comparison in *testing other resistances.*

Standard Telephone Switchboard.—A multiple telephone switchboard erected in keeping with all standard requirements for the best practice.

Standard Time.—A uniform standard of time adopted in the United States, in 1883, especially for the use of railroad and telegraph systems. This standard divides the country into four time sections, each 15° of longitude in width and differing in time exactly one hour from the next adjacent section: the time within the section governed by the 75th meridian is known as *eastern* time, that by the 90th meridian as *central* time, that by the 105th meridian as *mountain* time, and that by the 120th meridian as *Pacific* time.

Standard Wire Gauge.—A wire gauge adopted as a standard for electrical measurements, such as the American wire gauge for copper wire and the Birmingham wire gauge for iron wire.

Star Connection.—A method of connecting the three windings of the armature of a three phase alternator, in which one end of each coil is joined at a common center while the other ends radiate from this center and are carried to three collector rings. This arrangement suggests the shape of a star or the letter Y, hence it is also known as the Y *connection.*

Star Current in Polyphase Circuits.—The current in any conductor of a polyphase circuit employing star connection.

Star Potential.—In a star connected polyphase system, the potential difference between any line and the common, or neutral point.

Star Three Phaser.—An alternator generating three phase currents whose circuits are joined by the star connection.

Starting Box.—A rheostat, contained in a case, provided with contact points and a switch arm for delivering current to a motor gradually, upon starting, by cutting out one resistance after another until the motor attains full speed; *a starting rheostat* or *coil.*

Starting Compensator.—A device consisting of two or three auto-transformers, with switches, for supplying an induction motor with low voltage currents at starting, and then, as the motor gains in speed, increasing the voltage by steps to that of the line; an *auto starter.*

Starting Current.—The current passed through the armature and field magnets of a motor at the moment of starting in order to produce the required starting torque.

Starting Motor.—A small motor sometimes used to bring the speed of rotation of a single phase motor up to the point of synchronism with the driving circuit before connecting it up.

Starting Rheostat.—A series of resistance coils suitably arranged so that they may be cut out of the circuit of a motor when starting; a *starting box* or *starting resistance.*

Starting Torque.—1. The torque exerted by the starting current of a motor to overcome the static friction of the motor at rest.

2. A turning moment possessed by polyphase induction motors at starting due to the reaction on the primary of the excessive secondary current.

Starting Valve.—A valve, together with piping arrangements, whereby live steam is introduced above or below the low pressure or intermediate piston of a steam engine, in order to move the engine should it be stopped in a position where steam cannot enter the high pressure cylinder; also known as *impulse valve*. Another arrangement, known as a *by-pass*, admits live steam to the intermediate or L. P. steam chests, fulfilling the same purpose; these devices are usually fitted to all multiple expansion engines.

Static Balance.—In duplex telegraphy, a static capacity imparted to the artificial line to balance that of the main line.

Static Breeze.—A current of air produced by the convective discharge of electricity from the tip of a pointed conductor.

Static Compensator.—In duplex telegraphy, a condenser employed to give to the artificial line a static capacity to balance that of the main line.

Static Discharge.—A *disruptive* discharge. A discharge of static electricity across a dielectric which takes place when the dielectric gives way under the mechanical stress of the electric lines of force. A static discharge takes the form of a spark bursting across the non-conducting medium.

Static Electricity.—A term sometimes applied to the electricity induced and retained in the plates of a condenser or that which is said to reside as a charge upon the surface of a body, as distinguished from *dynamic* or *current* electricity.

Static Energy.—Potential energy. The energy possessed by a body in virtue of its position, chemical properties or other conditions other than motion, as distinguished from *kinetic energy*.

Static Head.—In hydraulics, the height, from a given point, of a column, or body of water *at rest*, considered as causing or measuring pressure.

Static Induction.—A term sometimes applied to the electric *influence* exerted by an electrified body upon a not electrified body. A charged body placed near an insulated conducting body will *induce* electrification in the conductor across the intervening space. It is on this principle that influence machines for generating static electricity operate. Beginning with a small initial charge acting by influence, other charges are induced which are collected in the parts of the machine.

Static Magnetic Induction.—Magnetic induction produced in a stationary body by the action of a stationary magnetic field.

Statics.—That branch of dynamics which treats of the equilibrium of forces as opposed to *kinetics*. The forces acting upon a body are in equilibrium when they balance one another so that no motion is produced.

Static Shock.—In electro-therapeutics, a method of applying static discharges from Leyden jars to a patient seated upon an insulated stool.

Static Transformer.—A term applied to an ordinary transformer for changing voltages, as distinguished from a rotary transformer for changing alternating into direct currents or the reverse.

Static Voltmeter.—Usually called *electrostatic* voltmeter, an instrument for measuring electromotive force, indicating the potential by a pointer moving over a scale reading in volts. A high voltage type is provided with an aluminum needle resting vertically on knife edges between two pairs of electrically connected quadrants. A multicellular type for lower voltages consists of a number of thin plates mounted horizontally between corresponding quadrants, the several plates serving to overcome the friction of the instrument by multiplying the force of deflection.

Stationary Motor.—An electric motor that has a fixed location, as distinguished from a traveling motor.

Stationary Tachometer.—A tachometer employed upon a machine which has a fixed location, to indicate the rotating speed of a shaft.

Stationary Transformers.—A term sometimes applied to a transformer to distinguish it from a so called rotary transformer.

Station, Electric.—The central plant for generating power for an electric system; *a power house*.

Station Indicator.—A voltmeter, or other indicating instrument, located at a central station.

Station Load.—The total electric pressure maintained at a central station.

Station Load Curve.—The characteristic curve tracing the variations of the station load during the course of the day.

Station Panel.—A panel of slate or marble upon which the switch gears of a central station are mounted.

Station Receiving Wattmeter.—A wattmeter employed at a central station for measuring and registering the power furnished by the plant.

Station Switch Gear.—In a central station, a compact group of switches, circuit breakers and measuring instruments through which the entire output of the station passes into the distribution system.

Stator.—1. In a dynamo or motor, the part which is fixed, as distinguished from the part which rotates.

2. In an induction motor, the fixed part, which is usually the field, as distinguished from the *rotor*, or rotating part.

Stator Armature.—In an induction motor, an armature which, instead of rotating, is fixed, while the field revolves around it.

Stator Coils.—The windings upon the stationary field of an induction motor, or, sometimes, the armature coils when the armature is fixed.

Stator Field.—The stationary field of a dynamo or motor.

Statute Mile.—The standard mile, equal to 5280 feet, legally established by statute in the United States and Great Britain, as distinguished from the *nautical* and other miles.

Stauroscope.—An optical instrument used to examine the position of the planes of light vibration of polarized light in crystals.

Stay.—In pole line construction, any contrivance for stiffening a pole against a transverse stress. A simple stay, or *guy*, consists in carrying a strand of wire from the pole to some nearby tree, or to an eyebolt set in a rock, to a log buried in the earth, or a short pole driven into the ground at an angle. An effective method is the use of a *guy anchor* which may be screwed into the ground to the required depth.

Stay Eye Clip.—An iron band, furnished with a ring, secured to a rigid support for the purpose of attaching a stay rod.

Steady Current.—An electric current flowing with unvarying strength.

Steam.—The vapor of water; the hot invisible vapor given off by water at its boiling point, this latter depending upon the pressure. The visible white vapor termed steam, is really a collection of fine watery particles, formed by condensation of true steam. When water is evaporated within a closed space, the process will continue up to a certain point, when the steam is said to be *saturated*, this signifying that no more steam can be made, unless the temperature be raised or the pressure lowered, by permitting some of the steam to escape.

The distinguishing properties of steam are: (1) Its fluidity, (2) its mobility, (3) its elasticity, and (4) its equality of pressure in every direction: that is, steam has a flow like water, it has a circulation within its own body, it is capable of compression and expansion, and when it is confined it presses equally upon all parts of the restraining vessel. Each molecule of steam is composed of two gases which have neither taste nor color. The difference in volume between water and steam at atmospheric pressure is as 1646 to 1; that is, a given quantity of water expanded into steam will occupy 1646 times the space it did before. This is nearly one cubic foot and one cubic foot of steam at atmospheric pressure weighs .038 lbs.

Steam is said to be: (1) *saturated* when its temperature corresponds to its pressure, (2) *superheated* when its temperature is above that due to its pressure, (3) *gaseous steam* or *steam gas* when it is highly *superheated*, (4) *dry* when it contains no moisture. It may be either saturated or superheated, (5) *wet* when it contains intermingled mist or spray, its temperature corresponding to its pressure.

Steam Dynamo.—A dynamo operated by a steam engine to which it is directly connected.

Steam Expansion.—Steam admitted to a cylinder during a portion of the stroke, then cut off, and expanded in the cylinder upon the piston, for the remainder of the stroke.

If the flow of steam to an engine be cut off when the piston has made half its stroke, that is, if it is used expansively, it has been ascertained that the efficiency will be increased one and sixty-nine hundredths times beyond what it would have been if the steam at half stroke had been released into the atmosphere, and so on, as expressed in the following (approximate):

TABLE.

Cutting off at $\frac{1}{10}$ the stroke, efficiency is increased 3.3 times.
Cutting off at $\frac{1}{8}$ the stroke, efficiency is increased 3 times.
Cutting off at $\frac{2}{10}$ the stroke, efficiency is increased 2.6 times.
Cutting off at $\frac{1}{4}$ the stroke, efficiency is increased 2.386 times.
Cutting off at $\frac{3}{10}$ the stroke, efficiency is increased 2.2 times.
Cutting off at $\frac{3}{8}$ the stroke, efficiency is increased 1.08 times.
Cutting off at $\frac{4}{10}$ the stroke, efficiency is increased 1.02 times.
Cutting off at $\frac{1}{2}$ the stroke, efficiency is increased 1.69 times.
Cutting off at $\frac{6}{10}$ the stroke, efficiency is increased 1.5 times.
Cutting off at $\frac{5}{8}$ the stroke, efficiency is increased 1.47 times.
Cutting off at $\frac{7}{10}$ the stroke, efficiency is increased 1.35 times.
Cutting off at $\frac{3}{4}$ the stroke, efficiency is increased 1.28 times.

The theoretical values given in the above table are largely reduced in practice, chiefly by condensation which increases with the expansion ratio. On this account it is not advisable to expand steam more than four or five times in one cylinder non-condensing, nor more than six or seven times condensing. Tests have shown that the efficiency is not increased by exceeding these limits. For higher expansions additional cylinders are used, thus dividing the temperature range and reducing the total condensation.

Steam Governor, Electric.—An electrical device for regulating a steam engine so that it shall drive a dynamo at a constant rate of rotation.

Steaming Lights.—The lights carried on either side of a steamship.

Steam Loop.—An arrangement of piping, resembling a double syphon, by which water of condensation is returned to a steam boiler. It is necessary that the *drop leg*, or return pipe, be sufficiently high for the weight of water therein to overcome the difference between the boiler pressure and that in the apparatus. The *horizontal pipe*, corresponding to the bend of the syphon, must also slightly condense the steam, occasioning a fall in temperature at the head of the loop. This condensation causes a slight reduction in pressure which draws up the exhaust steam and the condensed water from the heating system, the latter traveling up the *rise pipe*, intermittently, in the form of *slugs*. As the water accumulates in the drop leg, its weight forces it past the check valve into the boiler.

Steam Passages.—The steam and exhaust ports of an engine cylinder through which the steam obtains ingress and egress. They should bear constant proportion to the size of the cylinder and the rate of travel of the piston, together with ample allowance for loss of friction due to bends in the pipes, their size being such that there should not be any material difference in the pressure of steam in the cylinder and in the passages. An excess of size should always be given them. The ports are usually proportioned so that the velocity of steam will be 6000 ft. per minute through the steam ports and 4000 ft. per minute through the exhaust port, the calculations being based on steam velocities *before* expansion.

Steam Turbine.—A motor in which rotary motion is obtained by the action of steam impinging upon blades or vanes set upon the circumference of a drum or ring, which works within a suitable casing. Steam turbines may be classified as *reaction* or *impulse*.

Steam Turbine Dynamo.—A dynamo operated at a high rate of speed by a steam turbine.

Stearns' Duplex Telegraphy.—A system of duplex telegraphy operated by alternately placing the line to ground and to the battery, so that there results an "increase and decrease" of current on the line.

Steel.—A compound of iron containing 0.25 to 3% of carbon, usually with small quantities of silicon and manganese. The carbon causes it to harden when cooled suddenly from a red heat, and to soften again when cooled slowly. Steel classed as mild or ingot steel, is so made by a fusion process, which frees it from intermingled slag.

The more highly carbonized varieties, such as *crucible* and *shear steel* are used for tools, weapons and springs, their properties of hardening and tempering being invaluable. Modern research has led to the employment of less highly carbonized or mild steels in a variety of forms, either as castings or as forgings or rolled sections, thus displacing cast and wrought iron. Other metals, such as chromium and nickel are mixed with steel, increasing its tenacity and toughness to a remarkable extent. *Bessemer steel, open hearth process, mild steel, nickel steel*, etc., are varieties.

Steel Alloy.—In the construction of electrical machinery, an alloy of steel and nickel, or some other metal, employed where great mechanical strength and best magnetic qualities are demanded. Such forgings are costly and hence are used only when absolutely necessary.

Steeling.—The electro-deposition of iron, or steel plating. It is used to deposit a thin surface of iron upon a copper electrotype or other printing plates of soft metal in order to harden them, so that repeated impressions may be printed without wearing away the surface.

Steel Plating.—The electroplating of soft metal with a coating of iron to provide a good wearing surface. The process is

employed to coat printing plates so that an indefinite number of impressions may be taken from them without showing wear; also called *steeling*.

Steel Wire.—In electric transmission, steel wire is used for very long spans where high tensile strength is required. The resistivity of steel wire is 9 to 12 times that of copper. It must be galvanized to prevent rust.

Steelyard Ammeter.—A form of ammeter provided with a graduated steelyard arm carrying a sliding weight, and a solenoid suspended from the short end of the arm, so that when the current through the solenoid draws down the arm, the weight may be moved along the scale till a balance is reached.

Steeps.—In electroplating, solutions into which objects are dipped for a final cleansing before they are suspended in the plating bath. Also called *dips*.

Steering Compass.—The mariner's compass by means of which a vessel is steered at sea.

Steering, Electric.—Operating a ship's steering gear by electrical apparatus.

Steering Telegraph.—A telegraph system installed in a ship for sending steering instructions from the bridge to the wheel.

Steinmetz, Charles Proteus.—Born 1865. A German-American electrical engineer, scientist and mathematician, distinguished for his researches in electricity, especially in connection with alternating currents, electrochemistry, magnetism and hysteresis, dielectrics, and the theory of electrical phenomena. Coming to America as a young man, he began work as a draftsman. By contributing to electrical journals he soon attracted notice which ultimately led to his engagement by the General Electric Co. Here opportunity for experiment led to many inventions which already number over 100, and the development of extensive laboratories where researches of great importance are carried on. His brilliant mathematical mind is productive of most advanced contributions to electrical knowledge, and his books and papers are of the highest authority and everywhere recognised.

Steinmetz's Law.—A law of hysteresis loss determined by C. P. Steinmetz. It states that the loss by hysteresis is proportional to the one and six-tenths power of the flux density.

Stem.—1. The central pin or spigot of a mushroom valve, which works within a hole in the perforated seat, constituting the guide for the valve.

2. A rod working through the stuffing box of a slide valve casing, one end being connected to the valve by means of a nut or yoke, the other end being jointed to the valve gearing; what is usually known as a *valve spindle*.

Steno-telegraphy.—A "short hand" system of rapid telegraphy for press dispatches, employing a code of single and double letters and contractions in place of words and phrases; the signals being received by an ink recorder, and then written out by the operator.

Step By Step Telegraphy.—A system of printing telegraphy operated by the movement of a transmitter which sends out pulsating currents, causing a type wheel at the receiving end to respond step by step for each oscillation.

Step Down Transformer.—A transformer for changing alternating currents of small quantity and high pressure into currents of large quantity and low pressure; also called *step down converter*.

Step of Screw.—The distance between two adjacent threads, more commonly termed *the pitch of the screw*.

Step Up Transformer.—A transformer for changing alternating currents of large quantity and low pressure into currents of small quantity and high pressure; also called *step up converter*.

Stereopticon.—A perfected and elaborated form of magic lantern, consisting of a pair of lanterns combined into a single instrument.

Stereoscope.—An optical instrument by means of which two nearly identical photographs of an object are seen simultaneously through lenses so that the object appears in relief as in nature.

Stereotype.—A duplicate of a form of type or cuts, is made by moulding the form in plaster, clay, or papier-maché, and applying melted stereotype metal to make the plate.

Sterilization, Electric.—Destroying germs in a liquid by passing electric currents through it.

Stern Sheave.—In cable laying operations, a sheave or drum over which the cable is paid out from the stern of the cable ship.

Stethoscope.—A tube fitted at one end with a microphone or telephone receiver by which waterworks inspectors are able to listen at *night*, to the flow of water through the mains, thus being able to detect waste or leakage. The use of the stethoscope is naturally accompanied by closing out various streets so that the passage of water can point accurately to the thoroughfare along which undue consumption or leakage occurs.

Sticking.—In telegraphy, a tendency of the relay to cling to the pole of its magnet after the current is broken.

Sticking of Armature.—A clinging of the armature of an electromagnet to its poles after the magnetizing current has ceased in its windings.

Stiff Field.—A term sometimes applied to an intense electromagnetic field.

Stimulus of Nerve.—In electro-therapeutics, the excitation of a nerve produced by an electric current.

Stock Brick.—A hard, well burned brick, not quite perfect in form.

Stock Ticker.—A "step by step" printing telegraph in which a transmitter sends pulsating signals which are responded to by a type wheel maintained in synchronism, so that letters and figures corresponding to those transmitted are automatically printed upon a paper ribbon.

Stock Ticker Service.—A system of telegraphy for transmitting quotations of stocks to different points by means of stock tickers.

Stone.—A mass of concreted, earthy, or mineral matter. In popular language, very large masses of stone are called rocks; small masses are called stones; and the finer kinds gravel or sand.

Stone Cement.—1. A hard composition of the nature of mortar which will harden and form a water tight joint.

2. A mineral compound for uniting stone and resisting water, is made by mixing 19 pounds of sulphur, with 42 pounds of powdered glass or stoneware. Over a gentle heat the sulphur melts and the whole is stirred till a homogeneous mass is obtained when it may be run into moulds. It melts at 248 degrees Fahr.; it may be reformed indefinitely by remelting.

Stopper Lamp.—An incandescent lamp having a stopper mounted filament.

Stopper Mounted Filament.—An incandescent lamp filament which, instead of being sealed into the bulb, is mounted upon a form of stopper which is plugged tightly into the chamber.

Stopping Off.—In electroplating, the application of a coating of insulating varnish to certain parts of a metallic object, in order to prevent the deposit of plate upon those parts.

Stopping Off Varnish.—In electroplating, a non-conducting varnish employed to cover any part of an object which is not to be plated.

Stepping Out.—In electrotyping, the application of a coating of hot wax or a hot iron to the parts of a mould which are not to be reproduced in the electro.

Storage.—The artificial holding back of a body of water; as, to control the flow of water; as, in electro-hydraulics.

Storage Battery.—A source of electricity made up of a group of storage cells; a *secondary*, as distinguished from a *primary* battery. Each cell of a storage battery contains a positive electrode or plate provided with lead peroxide (PbO_2) as its active material, and a negative plate of sponge lead (Pb) immersed together in an electrolyte of dilute sulphuric acid. These elements are held in a containing cell or jar composed of glass, hard rubber, lead lined wood or any other acid proof water tight material, insulated from the other cells and resting on insulated supports. The storage cell is charged by a current of electricity which performs chemical action upon the elements. When discharging, the chemical action is reversed and an electric current is derived from the cell ranging from 2.1 volts at the start, to 1.75 volts when the cell requires recharging.

In all lead storage batteries, one of the objects desired is to obtain a large lead surface for small mass, as the capacity and discharge rates are strictly proportional to the amount of surface involved. This necessary maximum of surface has hitherto been obtained in one of two ways. The earlier method was to slowly eat out the lead plates by electrolysis until they had attained the requisite spongy condition, an affair of some time and expense. The later way (and the one which is generally practiced) is to cast a frame of lead, with raised right angled ribs on each side, thus forming little depressed squares, or to punch a lead plate full of holes, which squares or holes are then filled with a pasty mixture of red oxide of lead in positive plates, and with litharge in negatives. The manufacturer of one of the most efficient types of battery gives the following data:

Discharge in Amperes Per Hour During		Ampere Hour Capacity When Discharged in		Normal Charging Rate	Outside Dimensions of Jar in Inches		
8 Hrs.	5 Hrs.	8 Hrs.	5 Hrs.		Height	Length	Width
6¼	8¾	50	43¾	6¼	10½	5½	4¼
7½	10½	60	52½	7½	11	7¼	4¾
8¾	12¼	70	61¼	8¾	12½	7¾	4¾
10	14	80	70	10	12	6¾	7
12½	17½	100	87½	12½	12	6¾	7
15	21	120	105	15	12½	6¾	7
17½	24½	140	122½	17½	12½	6¾	7
20	28	160	140	20	12½	9¼	5¾
22½	31½	180	157½	22½	12½	9	6½
25	35	200	175	25	12½	9	6½
27½	38½	220	192½	27½	12½	9	6½
30	42	240	210	30	12½	9	6½
37½	52½	300	262½	37½	12½	9½	7½
45	63	360	315	45	12½	9	8½
52½	73½	420	367½	52½	12½	11½	8

Storage Battery Meter.—A form of meter for measuring the amount of electrical energy accumulated in a storage battery.

Storage Battery Traction.—Electric traction by means of storage batteries carried on the cars. Many attempts have been made to introduce this method of propulsion, but none have proved successful. The great weight of the cells, the acid fumes that arise from them, and their rapid deterioration under vibration have been the chief drawbacks to their use. Batteries are, however, sometimes usefully employed to drive industrial locomotives in manufacturing plants.

Storage Capacity.—The amount of electrical energy in terms of ampere hours which a storage battery is capable of delivering.

Storage Cell.—A cell in which the potential energy of chemical change is stored up to be given out again in the form of electrical energy by the action of a secondary chemical change. A storage cell, consists, usually, of a vessel containing prepared plates of lead immersed in dilute sulphuric acid, so that when a reverse electric current is sent through it, a chemical action charges the plates with chemical energy ready to deliver a current when required: an *accumulator* or *secondary* cell, as distinguished from a *primary* or *voltaic* cell: two or more storage cells connected so as to form a unit are called a *storage battery.*

Storage of Electricity.—The storing of the energy of chemical change produced by an electric current in a storage cell, so that electricity is yielded again by a subsequent secondary chemical change.

Storm, Electric.—An exceptional disturbance in the earth's magnetism which sometimes occurs from unknown causes. It is evidenced by unusual irregularities in the magnetic compass, and by extraordinary displays of the aurora; *a magnetic storm.*

Stove Plate, Electric.—An iron plate furnished with electrical resistance on its under side, so that it may be sufficiently heated for cooking purposes.

Straggling Flux.—The magnetic flux which escapes from the pole face of a dynamo electromagnet by any other path than across the air gap to the armature; the *leakage flux* as distinguished from the *useful flux.*

Straight Away Bunched Cable.—A bunched cable in which the conductors are arranged in parallel lines instead of being twisted together.

Straight Connector.—A form of connector for joining two wires in a straight line.

Straight Edge.—1. A bar of metal carefully planed and scraped on one or more edges to serve as a gauge or test for the accuracy of machine work, or in adjusting or assembling machinery.

2. An engineer's steel rule, the edges of which are made straight for use as a *gauge* or *tester.*

Straight Filament.—A straight form of incandescent lamp filament, as distinguished from the usual looped filament.

Straight Line Insulator.—A form of trolley hanger provided with extension lugs for the attachment of the wires used in connection with span wires where the line is straight.

Strain.—The deformation of a body resulting from a *stress.*

Strain Insulator.—In trolley line suspension, a form of insulator used at the point where the span wire supports the trolley wire. It is designed to bear the tension or strain on the span wire, and consists, in its simplest form, of an insulated ball or cylinder with an eye-bolt at each end.

Strain Sheets.—An engineering term applied to the various sheets of drawings and calculations, used to determine with

the utmost attainable accuracy the strength of the members, both iron and wood, of a structure; as, of a bridge or roof.

Stranded Conductor.—A conductor made up by twisting or braiding together several strands of wire, either to secure greater flexibility or to lessen self-induction.

Stranded Core.—A cable core made up of a number of conductors twisted together, as distinguished from a solid wire core.

Stranded Line.—A line wire consisting of a number of small wires stranded together.

Strap.—A polishing belt used by electroplaters, burnishers and brass finishers. Sometimes made endless, of two thicknessess of duck with india rubber between, but generally of heavy cotton duck, supplied in widths from one to six inches, the ends being sewed together. Emery powder, quartz, flint, or other abrading and polishing agents are used on the straps.

Strap Brake.—A simple variation of the Prony brake for testing the horse power of engines. A strap or piece of belt furnished with shoes is so disposed around the fly wheel as to form a ∩; the curve enclosing at least half the circumference of the wheel, while a steelyard is interposed between either end and the floor or foundation. An arrangement is made for adjusting the tension on the tight side of the strap, so as to insure a fair pull, and the product of the difference between the indications, on the two spring balances, multiplied by the linear velocity of the rim, in feet per minute, gives the power supplied by the engine.

Strap Coppers.—Copper strips used as the conductors of a bar armature.

Strap Driven.—A term sometimes applied to machinery to which power is transmitted from the prime mover by belting through a system of shafting and pulleys: *belt driven.*

Strap Key.—A key making electrical contact by means of an elastic strip which is secured to the base at one end and provided with a button at the other.

Strap Switch.—A term sometimes used for the simplest form of knife switch, consisting of a blade of copper hinged at one end and making contact at the other end between flexible copper jaws.

Strata.—The plural of *stratum*, folds or layers. A term applied to those rocks, among the constituents of the earth's crust, which present the appearance of successive layers piled upon each other. Such rocks have been deposited under water as the sediment resulting from the disintegration of older materials, and have hardened into stone; the succession of beds has been due to the rise and fall of the earth's surface, whereby the same area has been alternately sea and land, each change causing the deposition of a different stratum. The action of the same internal forces has produced tiltings, contortions and curvature in what were once horizontal layers.

Stratham's Fuse.—A variety of fuse for igniting an explosive by means of an electric spark.

Stratification Tube.—A low vacuum tube provided with electrodes between which, when a current passes, luminous effects appear, broken up into *striae* or stratifications of light, vibrating between dark spaces.

Stratified Discharge.—The luminous discharge, consisting of stratifications or *striae* of light, which takes place in a low vacuum tube at a certain degree of exhaustion.

Stray Chain.—In submarine cable operations, a section of chain by means of which the end of a cable may be fastened to a buoy or anchor.

Stray Currents.—1. Currents induced in the mass of a metal either by being cut by a moving magnetic field or by moving in the field. These currents circle about within the metal, absorbing energy and converting it into heat. They are usually called *eddy* currents, and sometimes *Foucault* currents after a French experimenter who investigated them. Eddy currents are the cause of much loss of energy in dynamos, motors and transformers. To obviate them, iron cores of armatures and induction coils are *laminated* or built up of thin metal stampings, the plane of division being arranged to lie parallel to the lines of magnetic force and at right angles to the direction the induced currents would tend to flow.

2. Currents which leak away from a street railway system through the ground, following underground pipes and other buried conductors, disintegrating and otherwise damaging them by the electro-chemical action known as electrolysis.

Stray Field.—A part of an electromagnetic field which fails to find its way through the armature, being dissipated by leakage; *a waste field.*

Stray Flux.—Lines of force which follow a stray path or leak from an electromagnetic

machine, and are wasted. In a generator or motor certain lines of force pass from one pole piece to another through the air or through the frame instead of through the armature; *leakage flux*.

Strayless.—A term applied to an electric or magnetic circuit or apparatus in which no leakage of flux occurs.

Stray Power.—The mechanical energy which is expended in overcoming the friction of the various parts of a machine.

Streamers.—Streaks of pale light seen in connection with the aurora streaming in the direction of the magnetic north.

Streaming Discharge.—A form of disruptive discharge of very high frequency; *phantom streams*.

Streamings.—1. The flux in an electromagnetic or electro-static field.

2. The radiation emitted by radio-active substances.

Street Call Point.—A point where a fire alarm, or other *signal box* is located.

Street Car Motor.—A motor for propelling an electric trolley car. One end of the armature shaft of the motor is provided with a pinion which communicates its motion by means of a large gear to an auxiliary shaft provided with a pinion which, in turn, communicates its motion to another large gear placed upon the car axle. In order to insure the parallelism of these gears and pinions, one end of the motor is fastened directly to the car axle, the other end is supported by springs, which permits of a movement of the motor and does away with the jar and strain which would otherwise occur on the starting and stopping of the car.

Street Car Wattmeter.—A recording wattmeter for indicating the amount of electric power consumed by a trolley car.

Street Load Diagram.—In a system of electrical distribution, a diagram indicating the load for each street to which power is supplied.

Street Mains.—The principal conductors in a system of electrical distribution running through conduit systems under the streets, receiving current from feeders and distributing current to service wires along the line.

Street Railway, Electric.—Any system of electric traction for city streets.

Street Service.—1. In a system of electrical distribution, the service wires leading from the street mains to the cut out within a building.

2. In a system of street lighting the service wires leading from the mains to the lamps.

Strength of Field.—The *intensity* of a magnetic field. It is the force with which it acts upon a unit pole at any point. The unit of intensity is that which acts on a unit pole with a force of one dyne. Its symbol is $\varkappa$.

Strength of Magnet.—The magnetic force exerted by either of the poles of a magnet. The *strength* of a magnet is not the same thing as its "lifting power." The strength of a magnet is the strength of its poles. The strength of a magnet pole must be measured by the magnetic force which it exerts.

The lifting power of a magnet depends both upon the form of the magnet and on its magnetic strength. A horseshoe magnet will lift a load three or four times as great as a bar magnet of the same weight will lift. The lifting power is greater if the area of contact between the poles and the armature be increased. Also the lifting power of a magnet grows in a very curious and unexplained way by gradually increasing the load on its armature, day by day, until it bears a load which at the outset it could not have done. If the load be so increased that the armature is torn off, the power of the magnet falls at once to its original value. The attraction between a powerful electromagnet and its armature may amount to 200 lbs. per sq. inch.

Small magnets lift a greater load in proportion to their own weight than large ones. A good steel horseshoe magnet weighing itself one pound ought to lift twenty pounds weight. Sir Isaac Newton is said to have possessed a little lodestone mounted in a signet ring which would lift a piece of iron 200 times its own weight.

Strength of Magnet Pole.—The magnetic force exerted by either pole of a magnet depending upon the amount of free magnetism at that pole.

Strength of Materials.—A general expression for the measure of capacity of resistance, possessed by solid masses or pieces of various kinds, to any causes tending to produce in them a permanent and disabling change of form or positive fracture.

Materials of all kinds owe their strength to the action of the forces residing in and about the molecules of bodies (the molecular forces), but mainly to that one of these known as *cohesion;* certain modified results of cohesion, as toughness or tenacity, hardness, stiffness, and elasticity are

also important elements, and the strength is in the relation of the toughness and stiffness combined.

Strength of Solenoid.—The product, at any point in a solenoid, of the intensity of magnetization and the area of cross section at that point.

Stress.—The mutual action of one body upon another resulting in *a strain.*

Stress Flux.—Electrostatic flux exerting a mechanical stress upon *a dielectric.*

Stretcher.—In building, a brick laid in course parallel to the face of a wall, or longitudinally; those laid across are termed *headers.*

Striae, Electric.—Luminous bands alternating with dark spaces seen between the electrodes in a low vacuum tube at a certain degree of exhaustion.

Striking.—The use of the *striking bath* in silver plating.

Striking Bath.—In silver plating, a preliminary bath, containing a weak solution of silver cyanide and a large proportion of potassium cyanide, employed to give an instantaneous coating of silver over an article for the purpose of insuring a perfect deposit in the regular silver bath.

Striking Distance.—The distance between two electrodes of a spark gap across which a spark will jump. Induction coils are designated by their sparking distance; thus, a "10-inch coil" is an induction coil which can produce a spark ten inches long between the points or knobs attached to the ends of its secondary circuit.

Striking Gear.—The bar with lever, forks and fittings, by means of which the driving belt of a machine is shifted from the tight to the loose pulley, or vice versa. The lever that operates the striking gear is sometimes known as the *shifting lever.*

Striking Mechanism.—An electromagnetic coil placed in the main circuit of an arc lamp for automatically striking the arc when the current passes.

Striking The Arc.—Producing an arc in an electric arc lamp by bringing the two carbon tips together and then separating them, so that the current causes a spark which, by volatilizing some of the carbon, maintains the passage of the electric current.

Stringing.—In pole line construction, after erecting the poles and equipping them with cross arms, insulators, etc., the process of running the wires from pole to pole.

Strip Commutator.—A commutator composed of flat metal strips.

Strip Fuse.—The simplest form of safety fuse for breaking an electric circuit when the current becomes excessive. It consists of a thin strip of fusible metal provided with copper terminals by which it is screwed down to the terminals of the circuit. This type of fuse is usually known as the *link fuse.* It is rapidly going out of use, being superseded by the *enclosed* or *cartridge* type which is safer and more reliable.

Stripping.—Removing the layer of metal that has been deposited upon a plated article. It is effected, either by treating the article with a strong acid, or by suspending it as the anode in a stripping bath, and subjecting it to the action of electrolysis.

Stripping Bath.—A bath containing a metallic salt for the purpose of removing the plating from an article coated with the same metal as that in the solution, by the action of electrolysis.

Stripping Liquid.—A solution of metal employed as a stripping bath for removing the plating from an object that had been plated with the same metal.

Strip Resistance.—A resistance composed of *metal strips.*

Stroboscope.—An instrument for the study of periodic motion, especially of a rotating body by periodically interrupted illumination, either by electric sparks, or by a beam of light seen through a perforated disc.

Stroboscopic.—A moving perforated plate employed in a type of stroboscope for the study of *varying motion.*

Stroke.—The linear distance traveled in one motion by a piston or plunger, whether in an engine or pump. The entire movement of the piston, from one end to the

other of the steam cylinder. The respective strokes are distinguished as *up* and *down* strokes, or *front* and *back* strokes, the front stroke being toward the crosshead. In the United States, the stroke of a locomotive piston toward the front of the engine is called the *front stroke*. The term is also applied to the movement of the crosshead and other parts moving with the piston. The movement of a slide valve is called its *travel* or *throw*. The movement of an eccentric is called its *throw*. Confusion results from the improper use of the word throw which means the entire linear movement produced by an eccentric and not half the movement.

Strong Current Arrester.—An arrester designed to protect a line or instrument from the possibility of contact with a circuit containing a powerful current.

Strontium.—A white, malleable metal, of but little importance from a mechanical point of view, its salts being used in pyrotechnics to give a red glare.

Struck.—In electroplating with silver, the state of an object that has been subjected to a striking bath preparatory to the regular *plating bath*.

Structural Filament.—An incandescent lamp filament in which the fibrous structure of a carbonized organic substance is retained.

Structural Iron Work.—The cast iron, and cast and wrought steel work entering into the construction of a building, comprising posts, pillars, caps and bases; rolled joists; cast, rolled or built up girders; sectional iron bars, etc.

Structural Magnetic Flux.—A magnetic flux occurring in a magnetizable substance by the action of its molecules, which are regarded as individual original magnets influenced by an external magnetizing force.

Structureless Filament.—An incandescent lamp filament in which the original structure of a carbonized organic substance is wholly destroyed in the process of manufacture, and the filament rendered homogeneous carbon.

Strut.—Any part of a machine or structure of which the principal use is to hold things apart; the opposite of *stay* and *tie*. In general, any piece of a frame which resists thrust or pressure in the direction of its own length.

Struts.—In pole line construction, poles or stubs propped against a telegraph pole to sustain special strains.

Strutting.—1. Diagonal braces between the joists in a floor to prevent sidewise deflection; the pieces are frequently crossed over each other, forming an elongated St. Andrew's cross; at other times they may incline alternately in each direction, forming *herring bone* strutting.

2. Shoring by means of struts. A shore that approaches the horizontal is known as a *strut*.

Stud.—1. A short rod, fixed in and projecting from something; sometimes forming a journal.

2. In machine shops, a boss or protuberance designed to hold an attached object in place.

3. In carpentry, an upright scantling.

4. A nail with a large head.

5. In a chain, a cast iron brace across the minor diameter of a cable link, to prevent collapse.

Stud Bolt.—A bolt with threads on both ends to be screwed into a fixed part at one end and receive a nut upon the other.

Stuffing Box.—An arrangement for rendering a joint tight where a movable rod passes into a vessel of some kind; as, the cylinder of a steam engine. It consists of a closed box, cast round the hole through which the rod passes, in which is laid round the rod and in contact with it, a quantity of hemp or india rubber packing, metallic or rubber rings, and the like, lubricated with oily matter, and pressed closely down by a ring.

Sturgeon, William.—Born 1783, died 1850. An English electrician; inventor of the first soft iron electromagnet (1825), the process of amalgamating the zinc plate of a voltaic cell with mercury (1830), the first rotating electromagnetic machine for effectually transforming electrical energy into mechanical power (1832), and later, the commutator, an indispensable part of a dynamo armature.

Sturgeon's Commutator.—An early form of commutator for a dynamo armature, consisting of a split copper tube.

Sub-aqueous Cable.—A form of underwater cable designed to be laid across rivers, lakes and other small bodies of water, as distinguished from a submarine cable; also called *a sub-fluvial* cable.

Sub-branch.—In electric wiring, a minor branch taken from a branch wire.

Sub-contractor.—A person or firm who contracts to execute minor details, or separate portions of any work which has been contracted for as a whole by larger firms; thus, in building a house, the painting and plumbing would usually be let by the builder to separate persons engaged solely in that class of work.

Sub-exchange.—A local telephone exchange, as, for example, an exchange for serving the telephones in a single building, as distinguished from a central exchange.

Subfluvial Cable.—An electric cable designed to be laid along or across the bottom of a *river*, as distinguished from a *submarine* cable intended for deep sea work.

Sublet.—1. To let work that one has contracted to do, to a subordinate contractor; underlet.

2. To let, or lease to another, property that one holds by a lease; sublease.

Sublimate.—In physics, to bring by heat into the state of vapor, which, on cooling, returns again to its natural state.

Sub-mains.—Electric conductors branching from mains, and themselves serving other branches.

Submarine Board.—A telegraph set for submarine telegraphy, mounted upon a board.

Submarine Boat.—A boat for naval warfare, propelled and manoeuvered under water by electricity.

Submarine Cable.—A telegraph cable consisting of stranded copper wires surrounded by insulating material, and protected by a sheath of steel wires, for use in submarine telegraphy.

Submarine Finder.—An apparatus, on the principle of the induction balance, designed to indicate the location of metallic objects under water.

Submarine Fuse.—A fuse for the purpose of exploding a torpedo or submarine mine.

Submarine Mine.—In naval warfare, an explosive mine placed under water, and fired by an electric current from the shore when an enemy's vessel passes over it.

Submarine Searchlight.—A powerful incandescent lamp designed for use in diving operations.

Submarine Telegraph.—A device whereby messages are electrically transmitted through copper wires laid at the bottom of the sea. The wires are insulated in gutta percha, tarred manila, and gutta percha again; those cables near the shore, which are subject to chafing on the rocks, being further protected by an armoring of plaited steel wires. The conductor is usually of purest copper wire, weighing from 70 to 400 lbs. per nautical mile, made in a sevenfold strand to lessen risk of breaking. In the Atlantic cable, which is of the usual type of cable for long lines, the core is protected first by a stout layer of gutta-percha, then by woven coating of jute, and outside all an external sheath made of ten iron wires, each covered with hemp. The shore ends are even more strongly protected by external wires.

Culley states that when a current is sent through an Atlantic cable from Ireland to Newfoundland no effect is produced on the most delicate instrument at the receiving end for two-tenths of a second, and that it requires three seconds for the current to gain its full strength, rising in an electric wave which travels forward through the cable. The strength of the current falls gradually also when the circuit is broken.

Submarine Telegraphy.—Telegraphic communication carried on between countries separated by large bodies of water, by means of cables laid upon the bed of the ocean.

Submerged Pump.—1. One that works entirely under water; as, in draining flooded mine workings, compressed air or hydraulic pressure being used as a motive power.

2. A pump which is so arranged that its feed supply is at a higher level than itself, insuring its chambers being full of water at each stroke, hence there is no lift, and the foot valve is generally dispensed with, the head and bucket valves being sufficient.

Sub-permanent Magnetism.—The magnetism acquired by an iron or steel ship during construction, which, in the course of time is gradually lost, until there remains finally a constant magnetic condition in the vessel known as its permanent magnetism.

Subscriber's Indicator.—A telephone switchboard drop indicating the call of a subscriber.

Sub-station.—A distributing or generating plant secondary to a central station, and located at a point in the system remote from the principal station.

Sub-station System.—In electrical distribution by means of transformers, an arrangement in which transformers fed by high pressure currents, are located at advantageous points, having their secondaries joined to a complete network of low-pressure distributing mains.

Substitution Method.—In the measurement of electric resistances a method in which a current of definite value is produced in a circuit containing the *unknown* resistance, and then there is substituted for it a *known* resistance of such value as to give the same current. The unknown resistance will then be the same as the known resistance.

Subterranean Mine.—An explosive mine placed underground, and ignited by an electric current from a distance.

Sub-transformer Station.—In a system of electrical distribution by means of transformers, the points where transformers are located for supplying low pressure currents to a network of distributing mains.

Subway.—1. An underground passage or footway, for facilitating safe transit from one side to another of crowded thoroughfares, or from one platform of a railway station to another.

2. A shallow underground urban railway, just below the surface level, reached from the street by a few steps only, like the Paris Metropolitan, the London Underground, or the New York Subway, as distinguished from a deep level line like the London Tubes.

Subway, Electric.—1. Underground tunnels for electric traction.

2. An underground passageway for containing electric cables and other conductors.

Successive Contact Key.—A key designed to close two or more electric circuits in succession.

Suction Gas Producer.—A type of gas producer in which draft is obtained by the piston of the engine during the suction stroke with open inlet valves, the vacuum so caused in the cylinder drawing the gas from the producer into the engine. The pressure in any part of the apparatus is never higher than that of the atmosphere.

Suction Gas Producer System.—The operation of a suction gas producer system depends upon the sucking action of the engine piston during its forward or charging strokes, which action tends to draw the air supply through the fuel bed of the producer, and the gas generated into the engine cylinder. The gases generated in the producer pass through an evaporator, which is practically a small multitubular boiler and furnish the sensible heat required for evaporating the water. The resultant vapor is conducted to the ash pit of the producer through a pipe by the sucking effect in the producer, while the gas passes from the evaporator to the scrubber filled with coke. As the gas rises through the interstices of the coke, the washing water descends and not only takes up and removes the dust brought over by the gas, but also clears it of ammonia and other impurities which have a tendency to combine readily with water. From the scrubber the gas passes to a receiver or *suction box.*

The diameter of the receiver being relatively much larger than that of the suction pipe of the engine, the strokes of the engine piston do not therefore cause pulsations between the receiver and the producer. The producer is usually provided with a charging hopper capable of holding enough fuel for several hours' operation, in the smaller sizes, and allows the admission of fuel to the combustion chamber without permitting access of air thereto during the charging operation. In operating, a fire is kindled upon the grate, the fuel bed built thereon, and the air necessary for starting combustion supplied by means of a hand or belt driven fan. The poor and lean gas produced at starting is first allowed to escape into the open air through a vent pipe until the test cock shows that good gas is being produced. This pipe is then closed and the scrubber and receiver are brought into the gas circuit. The engine is now put in operation and as it thereafter performs the function of the fan, the latter is stopped, the operation of the entire system becoming absolutely automatic.

Suction Lift.—In a pump, the height to which a column of fluid will rise in the suction pipe of a pump, due to the pressure of the external atmosphere. Theoretically this corresponds to about 34 feet with water, but the resistance of the valves, friction through passages, etc., together with the probability of minute leaks in the suction column, fix a maximum working limit of about 25 feet.

Suction Tube.—An air tight conduit or pipe fitted to parallel flow turbines, and discharging below the tail race. The advantage is that the turbine has equal efficiency if placed in any part of the pipe, as long as its height is not above 30 to 32 feet to balance the pressure of the atmosphere. By this device, the whole force of the fall may be utilised, yet the turbine is kept clear above the tail race, for overhauling and repair.

Suji Muji.—A term from the Hindustani, for a composition of lime and soda to remove old paint; a cleansing powder for washing paint work, etc.

Sulphate of Copper.—Copper sulphate, a compound of copper, sulphur and oxygen. In a crystallized form it is known as *blue vitriol* or *bluestone.* It is used in copper

plating, electrotyping, as the depolarizer in the Daniell primary cell, in dyeing and calico printing, etc.

Sulphate of Iron.—Ferrous sulphate. Also known as *copperas* or *green vitriol.* It forms bluish green transparent crystals which readily dissolve in water, and effloresce and oxidize in the air. In electroplating ferrous sulphate is used in the preparation of iron baths, and for the reduction of gold from its solutions.

Sulphates.—These are chemicals, formed by the action of sulphuric acid (commercially known as the oil of vitriol) upon an element, such as sodium, magnesia, etc.

Sulphation.—The deterioration of a storage cell due to the formation of lead sulphate over the surface of the plates. The lead sulphate is the product of the chemical combination of the active material with the electrolyte. It is a non-conductor, white in color and of greater volume, in proportion, than the active material. When the discharge of the cell is over prolonged, the sulphation is evidenced by the electrodes becoming lighter in color, because of the deposit of the sulphate which lessens the active surface, and, if further continued, by the loosening or breaking up of the active material or the "buckling" of the plates. Sulphation is usually the result of three principal causes: over-discharging, allowing the battery to remain discharged for a considerable time, or having wrong specific gravity of electrolyte.

Sulphur.—An elementary mineral substance of a yellow color, brittle, insoluble in water, easily fusible and inflammable; also called *brimstone,* that is, *burn stone,* from its great combustibility. It burns with a blue flame and a peculiar suffocating odor.

Sulphuric Acid.—A compound of hydrogen, sulphur and oxygen. The most important and widely used chemical in commerce, and its manufacture is one of the greatest of chemical industries. It is a colorless oily liquid, fuming slightly in air. It is very poisonous and corrosive. It forms the basis of manufacture of nearly all the other acids and salts, chemical manures and fertilizers, and is used largely in metallurgy, in the manufacture of certain papers, cellulose, explosives, coal tar colors and dyes, in tanning, refining and the preparation of various sulphates. In electric practice, sulphuric acid solutions are used as electrolytes in many primary cells and universally in storage batteries, and in electroplating, fuming sulphuric acid is used as a mixture with nitric acid for stripping silvered objects. Also called *oil of vitriol.*

Summer Lightning.—Also called *heat* lightning. A form of lightning flash, seen at the horizon as a sudden lighting up of the clouds without any sound of thunder. It is merely the reflection from a thunder storm taking place at too great a distance for the thunder to be heard.

Sunflower Commutator.—A form of disc armature with radiating parts resembling a sunflower.

Sunk Winding.—An armature placed in slots or channels sunk into the surface of the core.

Sun Spot Disturbance.—A disturbance of the earth's magnetism, such as a "magnetic storm," attributed to the occurrence of spots on the sun in an unusual degree.

Sun Spots.—Dark areas on the sun's disc which are observed to vary from time to time in size and number. They are due to the falling towards the center of the cooler matter from the higher regions of the sun's atmosphere.

Sunstroke.—Any affection produced by the action of the sun on some part of the body, especially a sudden prostration of the physical powers with symptoms resembling those of apoplexy, occasioned by exposure to excessive heat. Treatment: "Put patient in cool place, apply ice water and pounded ice in cloths to the head, back of neck and spine. In case more of exhaustion than of sunstroke, give stimulants gradually and be sparing of the ice and cold water."

Sunstroke, Electric.—A name given to the effect, resembling sun stroke, sometimes experienced by persons too long exposed to the light of an intense electric arc; treatment for this is same as for sunstroke, as given above.

Sun Telegraph.—The *heliograph,* an instrument for long distance signaling by flashes of sunlight reflected from a mirror. The signals are read from the distant station by means of a telescope, according to a prearranged code.

Sunwise.—In the direction of the sun's apparent motion, or from the east to the westward, and so around the circle.

Superficial Eddy Currents.—Eddy currents occurring upon the surface of a conducting body.

Superficial Magnetism.—Magnetism in a bar of iron or steel confined to the surface of the metal only.

Superheated Steam.—Steam having a temperature higher than that corresponding to its pressure; also called *surcharged steam*, and *steam gas*.

Superheater.—In steam engineering, an arrangement of tubes and headers placed in a boiler to impart heat to the steam in addition to that which it already holds as saturated steam, and thereby giving it power to do more work. This additional heat is imparted after the steam leaves the *dry pipe* and before it enters the steam chests.

Superheating.—In steam engineering, the practice of heating steam to a temperature above that due to its pressure. According to Barrus, who has made many engine and boiler tests, the saving in feed water for engines operating with superheated steam is about one per cent. for every eleven degrees of superheat. Superheating has been very successfully introduced in steam automobiles. According to tests of Prof. Carpenter, the White engine working with highly superheated steam, operates on less than eleven pounds of water per hour per *brake* horsepower, a performance only approached by large compound condensing Corliss engines, and quadruple expansion pumping engines.

Superimposed Magnetism.—Additional magnetization applied in order to increase the magnetization of iron or steel that has already been superficially magnetized.

Super-saturation.—The condition of a liquid holding in solution a larger quantity of a substance than it can normally retain when in a state of saturation.

Supervising Operators.—In a telephone exchange, operators of exceptional ability who have the supervision of the switchboard operators.

Supplementary Dynamo.—1. A small auxiliary dynamo familiarly known as the "*booster*," employed for maintaining the circuit at a constant value at some point remote from the main generator, especially for raising the voltage in long distance feeders.

2. In storage battery practice, a dynamo used to regulate the charge of the battery by raising the voltage of the bus bars to the necessary amount for charging. The field of the booster is reversible so that the battery voltage may also be raised during discharge if necessary.

Supplement of Angle.—The difference between a given angle and 180°.

Supply Mains.—In a system of electrical distribution, the mains which convey the current from the central station.

Supply Meter.—An instrument for measuring the amount of electric energy delivered to a consumer. Supply meters are known as *watt hour meters*, because they indicate the number of watts or kilowatts used during a certain period of time. Watt hour meters are also called *recording* or *integrating wattmeters* or simply *electric meters*. There are two principal types: (a) the *electro-chemical* which measure the amount of electrolytic action performed by the current, and (b) the *electromotor* in which a small motor is caused to revolve at a speed proportional to the rate at which energy is passing through it.

Supply Unit.—The unit of consumption of electric energy. It is known as the *watt hour*, being one watt expended for one hour. A larger and more convenient unit is the *kilowatt hour* which is equal to 1000 watts or one kilowatt expended in one hour. The kilowatt hour is known in Great Britain as the Board of Trade Unit.

Support Plate.—In a storage battery, the *grid*, a perforated or lattice work plate in the openings of which the active material is held. Grids are made in a very great variety, the object in all cases is to securely support the active material while at the same time exposing a large surface of it to the action of the electrolyte.

Surcharged Wall.—In civil engineering, a retaining wall, holding back an embankment of earth which slopes away upwards from the top of the wall.

Surface Action.—An action confined to the surface of a body.

Surface Carburetter.—A device for vaporizing gasoline for the fuel charge of an internal combustion engine. In its operation it produces a fuel mixture by passing air over the surface of a body of liquid hydrocarbon, or circulating it around a gauze wicking or metal surface saturated with such a liquid.

Surface Condensation.—In steam engineering, a system of condensing steam by cold metallic surfaces, in distinction to condensation by the injection of cold water, as with a jet condenser.

Surface Condenser.—An apparatus for condensing steam, especially the exhaust of a steam engine, by bringing it into contact with metallic surfaces cooled on the other side by water or air; an oblong or circular metal box fitted with horizontal tubes; at each end are fixed the tube plates, generally made of brass, and the tubes pass through the plates as

well as through a supporting plate in the middle of the condenser. Each end of the condenser is fitted with doors for the purpose of enabling the tube ends to be examined, drawn, or packed, as may be necessary. The tube ends are packed in various ways, and the tubes are made of brass, so as to resist the action of the water. The water is generally forced through the tubes by the circulating pump, and the steam is condensed by coming in contact with the external surface of the tubes.

Surface Contact Resistance.—The resistance offered at the contact surface between the metal plates and the solution in a primary or secondary cell.

Surface Contact System.—A system of electric traction employing a row of iron or steel studs projecting slightly above the roadway, and placed midway between the rails of the track so that a contact skate carried by the cars shall rub upon them and thus convey current to the motors.

Surface Density.—The quantity of electricity per unit area at a given point on the surface of a charged body.

Surface Wiring.—In the interior electric wiring of buildings, laying the wires along the outside of the plaster along the walls or on the under side of the ceilings without moldings, as distinguished from *concealed wiring.*

Surface Wound Armature.—An armature having its windings arranged over the surface of the core, instead of sunk in channels or grooves as in an iron clad armature.

Surge.—If an electric circuit be suddenly closed, a wave or surge rushes along the line. At the further end it rises to double the original voltage and is reflected back to the starting point where it is again reflected with falling pressure until the energy is dissipated by heat or leakage.

Surgical Lamp.—A miniature incandescent lamp of special design employed in surgery for exploring the cavities and examining the organs of the human body.

Surging.—When two alternators are working in parallel, but with slight variations in speed, a condition arises which is known as *hunting,* in which the machines alternately lag and lead with respect to each other. The current variations due to this hunting is known as *surging.*

Surging Circuit.—An electric circuit which is undergoing oscillations due to rapid charging and discharging.

Surging Discharge.—An *oscillatory* discharge. When a charged condenser is discharged through a conductor a series of extremely rapid oscillations or surgings take place, the condenser becoming positively and negatively charged in turn. An alternating current thus flows in the conductor and rapidly dies away as the energy of the condenser is dissipated.

Surinam Eel.—The common name for the *gymnotus electricus,* a South American eel possessing *animal electricity* in the highest degree known. The electric organ extends the whole length of its body and is capable of giving a powerful shock.

Surveyor's Chain.—A measuring appliance, for land surveying, made in different patterns, as:

1. *Gunter's chain*; this is 4 rods, 22 yards or 66 feet long $=\frac{1}{80}$th mile. It consists of 100 links, each link equaling 7.92 inches. Each tenth link is indicated by a brass tag; that for fifty links is circular and rather large, so as to be readily noticeable, the others are marked as follows from the center: 40 and 60 links four teeth on tag: 30 and 70 links, three teeth; 20 and 80 links, two teeth; 10 and 90 links, one tooth on tag. There are usually carried, with each chain, ten arrows for marking positions on the ground, each arrow being a pointed wire about 18 inches long, with a piece of red cloth tied to its ring.
2. *Ramsden's chain* of 100 feet long, each link being one foot in length.
3. *Décamètre chain* of 10 mètres long, each link being one décimètre or 3.93 inches. In most countries using the metric system, a chain of twice this length is generally employed, having a length of 20 mètres or 65.617 feet of 100 links, each measuring 7.874 inches.

Susceptance.—One of the two components attributed to the property *admittance* (the reciprocal of impedance) in an alternating current circuit, in which the power component is called the *conductance* and the wattless component the *susceptance.*

Susceptibility.—Magnetic susceptibility, the ratio of the intensity of magnetisation in a magnetised body to the magnetizing force. Its symbol is the Greek letter *kappa* (κ). If I equals the intensity of magnetisation and H the magnetizing force, then

$$\kappa = \frac{I}{H}$$

Suspension Ear.—A trolley ear; a device for suspending an overhead trolley wire. It is made in a great variety of forms, but consists essentially of a casting which is supported by the span wire or bracket, and, insulated from this casting, an ear that grips or is soldered to the trolley wire. A *plain ear* is used in ordinary work; a *strain ear*

has lugs for tension wires; a *feeder ear* is provided with a special lug for a tap from the feeder; and a *splicing ear* acts as a splice where the trolley wire comes to an end at a hanger.

Suspension of Motor.—The method of supporting a motor upon the truck of an electric car. There are three well known methods: (a) the *nose* suspension, in which the back of the motor is supported by the axle, and the front is carried by a crossbar resting on springs supported by the side frames of the truck; (b) the *cradle* suspension, in which the motor rests in a cradle which is supported in front by a cross beam joined to the side frames of the truck, and at the back by springs which bear on the arm that carries the axle bearing; and (c) *side-bar* suspension in which two parallel spring-supported side bars carry the weight of the motor either from above or below.

Suspension Railway.—A form of monorail road, in which the cars travel *underneath* the track upon which their wheels run. Such forms are convenient for transporting material within an area where it is desirable to leave the floor quite clear, the car being usually driven by an electric motor, which is controlled by an attendant sitting in the cage suspended from the trolley.

Suspension Wire.—A wire or cable usually known as a *messenger wire* from which an overhead conductor is suspended by means of cable hangers at intervals of a few feet, so that the tension of the sag between supports shall not fall upon the conducting cable itself.

Sustained Current.—An electric current that is maintained in a state of continued flow, as distinguished from a current of only brief duration.

Swage Block.—A form of anvil pierced with holes of different shapes, and provided with grooves of various sizes, for shaping hot metal too heavy to be worked with a swage on a regular anvil.

Swaging, Electric.—The use of a swage in imparting shape to metal which has been first softened by electric heat.

Sweating.—A term sometimes applied to the soldering of the ends of electric wires or cables in making a joint.

Sweep.—In submarine cable operations, a drag made along the sea bottom with a grapnel.

Sweeping Out Charge.—The clearing of the line in double current telegraphy by reversing the direction of the current to remove the charge after one signal before sending another.

Swelling Current.—In electro-therapeutics, a faradic current that is repeatedly increased in strength to its maximum, and then reduced to zero while applied to a patient.

S. W. G.—Abbreviation for *standard wire gauge.*

Swimming Rule.—A rule suggested by Ampère for determining the direction of lines of force with relation to that of the current which produces them. It may be stated as follows: Suppose a man swimming in the wire with the current and that he turns so as to face a magnetic needle placed near the wire, then the north-seeking pole of the needle will be deflected towards his *left* hand.

Swing Check.—In hydraulics, a check or non-return valve for a pump delivery pipe, having a swinging flap, hinged on one edge and closing against an inclined seat. *A clack valve.*

Swinging Cross.—In overhead lines, an intermittent contact which sometimes results from the swinging of a line wire against another.

Swinging Earth.—A faulty connection with the earth sometimes occasioned in an overhead circuit by the swinging of a line wire against a conductor leading to the ground; an *intermittent* earth.

Switch.—Any device by means of which an electric circuit may be opened or closed.

Switch Blade.—The conducting blade of a knife switch by means of which a circuit is closed.

Switchboard.—1. A panel or series of panels of slate, marble, soapstone or brick tile erected in an electric plant for the purpose of mounting in a convenient group the instruments for controlling and distributing the current and safeguarding the system. Two main types may be distinguished; the *direct control* switchboard having all its apparatus mounted directly on the board and controlled by hand, and the *remote control* switchboard in which the main current carrying parts are at some distance from the operating board, the control being effected by mechanical devices or by electric motors or solenoids. When the control system of a plant is very extensive, it sometimes occupies a separate building known as the *switch house.*

2. In a telephone exchange, a group of sections including the apparatus by means of which inter-

communication between subscribers is effected. The calling and answering jacks, the plugs, signal lamps, cord circuits, relays, etc., form the equipment of a telephone switchboard. In the larger exchanges, a *multiple* switchboard is used, in which each operator controls a certain proportion of the subscribers in a separate section of answering jacks, while every subscriber's line has a multiple jack duplicated at every section.

Switchboard Arrester.—A lightning arrester provided for the protection of a switchboard.

Switchboard Instruments.—The various instruments and meters employed in electric switchboard work. They include various types of ammeters, voltmeters and wattmeters, together with frequency and power factor meters and indicators, the wattless component indicator, synchroscope, ground detector, synchronizer, etc.

Switchboard Protector.—Any lightning arrester or safety fuse introduced into a circuit at a switchboard for the purpose of protecting the circuit from a powerful discharge or excessive current.

Switchboard Wattmeter.—A wattmeter mounted upon a switchboard for the purpose of determining the electrical output through a circuit connected with it.

Switch Box.—A box designed to hold switches used in electrical circuits.

Switched In.—Joined into an electric circuit by the action of a switch.

Switched Out.—Cut out of an electric circuit by the action of a switch.

Switch Fingers.—In a trolley car controller, the spring contacts which are fixed parallel to the cylinder, so that, as the cylinder is revolved, they make contact with the segments on the cylinder.

Switch Hole.—In a plug switch, the hole into which the plug is introduced.

Switch Hook.—In a telephone set, a device for alternately connecting the talking apparatus and the signaling apparatus with the line. The action is automatically made by using it to hold the weight of the receiver. When the receiver is lifted off, the hook rises and the circuit through the talking apparatus is closed to line and that through the bell and generator opened. When the receiver is hung up, the hook falls and opens the talking circuit, making connection again between the line and the ringer.

Switch House.—In large electric systems which require a numerous and complicated equipment of controlling and distributing apparatus, a separate building for housing the switchboards and devoted solely to switchboard work.

Switching Dynamo into and out of Parallel.—In order to put an additional dynamo into parallel with those already working, it is necessary to run the new dynamo up to full speed, and, where it excites, regulate the pressure by means of a hand regulator until the voltmeter connected to the terminals of the machines registers one or two volts more than the voltmeter connected to the lamp circuit, and then close the switch. The load upon the machine can then be adjusted to correspond with that upon the other machines by means of the hand regulator. In this class of machine there is little or no danger of overloading an armature when connecting it to the bus bars and therefore the pressure need not be adjusted with very great accuracy; in fact, it is common practice in central stations to judge of the voltage of the new dynamo merely by the appearance of its pilot lamp.

When shutting down a machine, the load or current must first be reduced, by gradually closing the stop valve of the engine, or inserting resistance into the shunt circuit by means of the hand regulator; then when the ammeter indicates nine or ten amperes the main switch is opened, and the engine stopped. By following this plan, the heavy sparking at the switch contacts is avoided, and the tendency for the engine to race reduced. Great care, however, has to be taken that the current is not reduced too far, or otherwise there is a risk of the machine being stopped, receiving a back current from the other dynamos, resulting in heavy sparking at the commmutator, and in the machine being driven as a motor. To obviate this danger, and to render these precautions needless, shunt dynamos when running in parallel are frequently provided with automatic cutouts, set so as to automatically switch out the machine when the current falls below a certain minimum value.

Switch Jack.—A term sometimes used for *spring jack*, a switch socket employed in a telephone switchboard for the purpose of admitting a conducting plug attached to a flexible cord by means of which connections are made with terminals contained in the jack.

Switch Pin.—In a plug switch, the plug or pin which is introduced into the switch hole.

Switch Spring.—A spring in the mechanism of a switch.

Syenite.—A rock having a structure mucn resembling granite, but containing no free quartz. The stone is hard and durable, of a fine grain and light gray color. The name is derived from Syene in upper Egypt,

where rock was quarried to build the vast monuments of the ancient Egyptians.

Symmetrical Alternating Current.—An alternating current having uniform frequencies of unvarying values.

Symmetrical Induction of Armature.—Magnetic induction that is symmetrically disposed throughout an armature.

Symmetrical Magnetic Field.—A magnetic field through which magnetic flux is uniformly distributed.

Sympathetic Vibrations.—Vibrations produced in a medium by vibrations of precisely the same period occurring in a neighboring medium or body; as when a resonator transmits electric waves through the universal ether in wireless telegraphy.

Synchronism.—A relation existing between two or more alternators such that the pressure waves generated by them are of equal period and corresponding phase, so that it is possible to successfully combine their output.

Synchronize.—To bring two or more alternators into such relation to each other that their pressure waves shall be of equal period and corresponding phase.

Synchronizer.—A device for indicating when alternating current machines are running in phase with each other. The simplest form is the connection of incandescent lamps across a switch in the circuit, when the machines are in phase the lamps will not light up. Another form is the synchronizing transformer joined to a synchronizing lamp. When the machines are in step the lamp is lighted. In place of the lamp a dead beat voltmeter is sometimes used. An instrument called the *synchroscope* is used in recent practice with large generators.

Synchronizing.—Regulating the operation of two alternating current machines, connected in parallel, so that they shall be identical and simultaneous both in frequency and phase.

Synchronizing Transformer.—An arrangement for indicating when two alternating current machines are operating together in phase. It consists of a transformer having a double primary winding and a single secondary across which is joined the synchronizing lamp. When the machines are in step the lamp is lighted.

Synchronous.—Simultaneous; to agree in time; motion of machinery arranged to correspond in time.

Synchronous Converter.—A *rotary converter*; a machine employing mechanical rotation for converting from an alternating to a direct current or *vice versa*. When used for changing from direct to alternating it is called an "inverted" converter. The synchronous converter is a synchronous motor and a direct current generator combined as a single machine.

Synchronous Drive.—In gas engine ignition, a high tension magneto must be driven "synchronously," which is to say, at a speed in ratio to that of the engine, generally at one half engine speed for a four-cylinder engine, in order that the spark may always occur at precisely the proper point in the rotation of the armature. The drive may be by toothed wheel gear or chain and sprocket. The friction gear drive or belt and pulley are alike objectionable, from the fact that no slipping or variation is permissible. While some recent forms of high tension magneto operate asynchronously, the common types are so made that the spark shall occur in the first cylinder at precisely the moment the magneto armature is at a certain point in its rotation. If, therefore, this condition be not strictly observed, the spark will be of defective intensity, and the control of the engine complicated.

Synchronous Dynamo.—An alternating current dynamo running in step, and with equal period, with another alternator.

Synchronous Motor.—An alternating current motor which has been brought up to synchronous speed and into step before being joined into circuit; it is practically an ordinary alternator run as a motor.

Synchronous Multiplex Telegraphy.—A system of telegraphy in which the instruments at each end of the line are caused to act in synchronism, so that it is possible to transmit four or more messages at practically the same time over the same wire.

Synchronous Polyphase Motor.—A polyphase motor running with period and phase equal to that of the generator driving it.

Synchronous Running.—The operation of two alternators connected in parallel so that they shall deliver current of the same frequency and the same phase.

Synchronous Speed.—The speed of a machine running at a rate corresponding

with that of other machines connected with it.

Synchronous Vibrations.—Vibrations which correspond exactly in period and phase.

Synchroscope.—An instrument employed to indicate when two or more alternators or motors are running in synchronism. It is in reality a special form of power factor indicator with a pointer free to rotate, and with no scale on the dial since only the point of synchronism is required. When the pointer becomes stationary and assumes the zero position, the main switch connecting the machines may be closed. Also called a *synchronizer*.

Synthesis.—The process of uniting elements to form a compound, as opposed to *analysis*.

Syntony.—In wireless telegraphy, the adjusting of the receiving apparatus of one station to the sending apparatus of another, so that when from a sending station waves of one frequency are radiated, the detector at another station shall respond only to the waves from that transmitter without interference from waves of other frequencies. This is done by making the oscillation constant of the receiving circuit the same as that of the sending circuits. Producing syntony between two circuits is also called "*tuning.*"

Syphon.—A bent pipe or tube with legs of unequal length, used for drawing liquid out of a vessel by causing it to rise within the tube, over the rim or top. The shorter leg is inserted in the vessel and the air exhausted from the longer leg, when the pressure of the atmosphere causes the liquid to fill the tube and run out of the lower end. This flow depends upon the difference in vertical height of the two columns of liquid, measured downwards from the bend, and ceases when they become of equal height or when the level in the vessel has fallen to the bottom of the shorter leg.

Syringe.—An instrument for forcing liquids, consisting of a tightly fitting piston working within a cylinder, one end of which is closed with a perforated cone, whose dimensions are suitable to the purpose of the syringe. On placing the cone in the water and lifting the piston, the atmospheric pressure drives the liquid into the cylinder; on pressing the piston back the water is forced out in a jet through the orifice. The cone may be replaced by a perforated plate, which sprays the liquid over a large area.

T.—Symbol for intensity of magnetization.

t.—Abbreviation for *time.*

Table Push.—A push button fitted to a table for ringing a call bell, or other similar purpose; *a desk push.*

Tablet Check.—In a telegraph office, a system of recording and checking off messages sent and received, upon a suitably tabulated form.

Tabulating Machine.—A mechanical device for tabulating statistics, as in census reports, etc. The various items with regard to each person are transcribed from a written report to a special card, being indicated on the latter by holes punched in determined positions. The punched cards are taken to a second machine, which has the number of plungers corresponding to any possible hole; the proper plungers pass through the holes in the card, and make *electrical contact* with a registering machine, which enumerates the items.

Tachometer.—1. In hydraulics, a device to show the swiftness of a current by its effect upon a submerged paddle or paddle wheel; a current meter having a rotating screw for driving clockwork, indicating the speed in miles per hour.

2. An indicator, to show at a glance the speed of rotation.

3. A device for showing the changes in the velocity of machines, by the action of mercury in a revolving cup.

Tailings.—In high speed automatic telegraphy, a running together of the signals, producing prolongations of the characters recorded upon the paper ribbon.

Tailrace.—In hydraulics, the channel by which water runs away after driving a mill wheel or turbine.

Talautoscope.—An instrument consisting of a partially exhausted tube, used in connection with an oscillator to determine whether electric waves are being properly projected or not.

Talc.—A soft silicate of magnesia, also called "soapstone." It is easily split into thin plates, but differs from mica in not possessing elasticity. It is used as heat resisting insulation in spark plugs and in other details of electrical apparatus.

Talking Circuit.—The circuit of the telephone talking apparatus as distinguished from that of the call bell, or calling circuit.

Tallow.—A substance composed of the harder and less fusible fats, obtained by rendering beef or mutton fat, as also almost any of the animal fats, and of certain vegetable fats.

Inferior kinds of animal tallow are known as "melted stuff," "rough stuff" and "town tallow." These are used in machinist's work for coating bright work to prevent corrosion. In lubrication, tallow should not be used unless of the very best quality, since with high pressure steam it becomes partially converted into oleic or stearic acids, which corrode the iron in the piston cylinders and steam joints.

Talus Wall.—In masonry, a wall inclined on its face, either by decreasing its thickness toward the summit or by leaning it against a bank, as a *retaining* or *breast wall.*

Tamping Bar.—In pole line construction, a bar, sometimes of iron, but usually of wood, with a broad base shod with iron, for the purpose of beating down the earth about the base of a pole immediately after its erection.

Tandem Engine.—A compound steam engine having two steam cylinders in a line with each other and attached to the same piston rod.

Tangent and Sine Galvanometer.—A compound form of galvanometer having a small needle for measurements by the tangent method, and a large needle for sine measurement.

Tangent Galvanometer.—A form of galvanometer consisting of a circular coil or ring, at the center of which is supported a small magnetic needle whose length does not exceed one-twelfth of the diameter of the circle; a current flowing through the coil will deflect the needle to such a degree that the tangent of the angle of deflection will be proportional to the strength of the current.

Tangential Brush.—A commutator brush that bears upon the surface of the commutator in the relation of a tangent to a circle. They are generally made of copper and used on generators employed for lighting purposes.

Tangent Scale.—The circular scale of a tangent galvanometer graduated into values of the tangents instead of into equal degrees of arc, in order to obviate the necessity of referring to a table of figures in making computations.

Tank Heater, Electric.—An arrangement for heating liquids, consisting of an electric resistance coil introduced into the tank which holds the liquid.

Tanning.—The process of impregnating the hides of animals with a solution of tannic acid, converting their gelatinous substance into a material that will not putrefy, and which may be either firm and hard or else soft and supple, according to the method employed.

Tanning, Electric.—Tanning hides in the preparation of leather by a process of electrolysis in which electric currents are caused to pass through the tanning liquor in the vats.

Tantalum.—A rare metal, resembling platinum in color, with a specific gravity of 16.5, and a melting point about 4100° Fahr. It is malleable, ductile and very tenacious. When repeatedly heated and flattened to a plate, under a steam hammer, it becomes so hard that a diamond will not bore it. It offers very little resistance to the electric current, and so, in view of its high melting point, it is used as a filament in incandescent lamps.

Tantalum Lamp.—A form of incandescent lamp having a filament composed of the metal tantalum. The bulb contains a central glass rod bearing two supporting rims from which radiate arms of nickel wire having hooks at the end over which the tantulum filament is suspended. As compared with the carbon filament lamp, the tantalum lamp will take much greater current at starting, will reach incandescence more quickly and will be much less sensitive to voltage variation, at the same time consuming less watts with greater candlepower.

Tap.—1. Any short branch conductor leading off from a larger conductor or main.

2. In quadruplex telegraphy the point where the tap wire divides the battery into the "long" end and 'short" end.

Taped Wire.—A wire, or conductor, wrapped with insulating tape.

Tape, Insulating.—An adhesive insulating material made by saturating cotton tape with a mixture of 30 parts coal tar and 40 parts resin. It is used for winding joints or electric conductors.

Tapered Mains.—In the "tree" system of incandescent electric lighting, mains which gradually diminish in size towards the extremities of the system.

Tapers.—Conductors which gradually diminish in diameter for splicing cables of different types.

Taping.—Applying a wrapping of insulating tape to a conductor or cable.

Tapper.—In single needle telegraphy, a double form of transmitting key, consisting essentially of two flat springs between two contact bars; *a pedal key.*

Tapper Bell.—A variety of electric bell which rings a single stroke with each depression of the signaling key.

Tapper Signal.—A signal transmitted by means of a tapper bell.

Tappet Valve.—1. A disc or mushroom valve operated by some device with which it is not positively connected; as, a cam or trip lever. The valves of an internal combustion engine are generally of this type.

2. A valve moved on its seat by means of a tap or blow from some other part of the mechanism. The slide valves of a single cylinder steam pump are usually of this description.

Tapping a Circuit.—Inserting a branch into a telegraph or telephone line for the purpose of appropriating information by listening to messages passing over the line.

Tap Wire.—1. In a trolley system, a conductor for connecting the feeders with the trolley wires.

2. In quadruplex telegraphy, a wire used to tap the battery and divide it into the "long" end and the "short" end.

Tar.—1. A very dark, oily liquid obtained in the process of distillation of various substances; that resulting from the distillation of resinous woods, which is used as a paint, a preservative of cordage, etc.; the product derived from gas manufacture, coke ovens, or other distillation of coal.

2 The residuum of petroleum left after the kerosenes or illuminating oils have been distilled off: the extent or nature of the residue depends upon the locality or the refined product demanded.

Target, Electric.—A target provided with an electrical arrangement for indicating upon an annunciator the result of each shot.

Tar Varnish.—In hydraulics, a protective coating used for pipes and structures which are laid under water. It is variously made, but is composed essentially of the bituminous products of coal mixed with mineral oils. One method is to mix 30 gallons of tar (coal) fresh with all its naphtha retained, 6 lbs. of tallow, 1½ lbs. of resin, 3 lbs. of lamp black, 30 lbs. of fresh slaked lime, finely sifted; mix and immediately apply hot.

Tasimeter.—An instrument for indicating slight changes in temperature, by the decreased electrical resistance of a soft carbon button under increased pressure.

Teak.—In timber, there are two woods thus designated, the one the African oak, the other the Moulmein or Indian, the latter the true teak. It is of a greasy nature and therefore does not corrode iron in contact with it. It contains siliceous matter which dulls the edge of cutting tools. It is of a light brown color, shrinks little, is durable, straight and rather open grained, stands heat well, and is not attacked by insects. A cubic foot weighs 46 pounds.

Teaser.—In a compound wound dynamo, a coil of fine wire wound upon the field magnets in addition to, and in shunt with, the field magnet series coil; or, a few turns of thick wire in series with the shunt winding of the field magnets.

Teaser Winding.—A second and smaller coil applied to the armature of a monocyclic alternator, connecting the center of the main coil with the collector ring.

Tee Box.—In underground cable construction, a junction box resembling the letter T, for connecting a branch at right angles with a main.

Tee Connector.—A connector shaped like the letter T for connecting a wire at right angles with another; *a T connector.*

Teeth of Armature.—In a slotted armature, projections upon the surface between which the coils are laid on.

Tel-autogram.—A telegraphic message recorded by a telautograph.

Telautograph.—A writing or copying telegraph for reproducing writing or drawings at a distance, by means of a receiving pen, which, directed by a complex mechanism, controlled by electric currents, follows the motions of a transmitting pen operated at the station of the sender. This is an invention of Elisha Gray, of Highland Park, Ill.

Tele-anemograph.—An anemograph having its electric recording apparatus situated at a considerable distance from the anemometer.

Tele-barograph.—An instrument for recording the changes of a barometer which is situated at a considerable distance from the recording apparatus.

Tele-barometer.—A barometer which electrically registers its indications by means of a tele-barograph at some distance from it.

Telefunken System of Radio-telegraphy.—A system of wireless telegraphy based upon the patents of German experimenters. An arrangement of wires similar to that designed by Marconi forms the aerial, and the earth connection is given by a large capacity as in the Lodge-Muirhead system. The coherer and receiving circuits resemble those of Marconi. The system has been promoted by the official recognition and influence of the German Government.

Telegram.—A message sent or received by telegraph.

Telegraph.—1. A system of communicating to distant points by a series of electrically transmitted signals.

2. To send a message by telegraph.

3. In navigation, an apparatus for transmitting orders from a ship's bridge to the engine room, poop, forecastle head or elsewhere. A series of endless chains passing over pulleys in the machines at either place, cause the pointer on one dial to assume a position corresponding to that on the dial whence the signal has been transmitted; a gong calls attention to the movement of the telegraph pointer. For small craft, torpedo boats, etc., the endless chains are replaced by *tubular rods* rotated by sector gearing.

Telegraph Alarm.—In needle telegraphy, a bell to call the operator's attention to the deflections of the needle upon the dial.

Telegraph Arm or Cross Arm.—A bar, usually of wood, attached horizontally to a

pole to serve as a support for the insulators carrying overhead electric wires.

Telegraph Bracket.—In overhead line construction, a bracket carrying an insulator for the support of a telegraph wire.

Telegraph Circuit.—The electric circuit employed in a telegraph system, consisting in its simplest form, of the battery, the line wire, the ground, and the necessary instruments.

Telegraph Dial.—In needle telegraphy, the dial upon which the needle or pointer indicates the signals.

Telegraph Dynamo.—A dynamo for the purpose of generating the electric currents employed in telegraphy.

Telegrapher.—A telegraph operator.

Telegrapher's Cramp.—A painful condition of a telegraph operator's hand, sometimes brought on by incessant constrained use of the same muscles in manipulating the key.

Telegraph Fixtures.—In overhead line construction, the lesser appliances employed in supporting telegraph wires.

Telegraphic Clock.—The standard clock which controls the movement in dependent clocks in a system of electric timekeeping; the primary, or controlling clock; a *master clock*.

Telegraphic Box Sounder.—A form of telegraphic relay for use in special cases, having a wooden box set over the coils in order to reinforce the sound of the signals so that they may be clearly audible; *a box relay*.

Telegraphic Codes.—Cipher systems, used in telegraphy for the sake of economy and secrecy. No cipher word may exceed ten letters, nor may it be a nonsensical or made up word, but one taken from civilized languages. Codes may be arbitrary or selective. In the former case, one word means a definite phrase or term, according to the vocabulary of the parties interested. With the latter, each word is regarded as a numeral of six to ten figures; each two figures represent a definite idea according to their position, the combinations being apparently numberless, yet easily translatable with the proper key. As an example, a message containing 144 code words, when translated, occupied 75 foolscap pages of typewritten matter.

Telegraphic Earth Circuit.—A telegraphic circuit completing its return through the ground; *a ground circuit*.

Telegraphic Interruption.—An interruption in telegraph or cable service due to accident or fault in the line.

Telegraphic Photography.—A system of reproducing a photographic representation at a distant point by telegraphy.

Telegraphic Splice.—A sleeve soldered over the joint between two cable lengths.

Telegraphing.—The act of despatching a telegram.

Telegraph Insulator.—A contrivance, usually of glass or porcelain, for supporting telegraph wires and preventing escape of current.

Telegraph Interrupter.—A telegraphic key for making and breaking the circuit.

Telegraph Joint.—Uniting the ends of two lengths of telegraphic wire by such methods of intertwisting, soldering, etc., as will secure uninterrupted conducting properties.

Telegraph Key.—The instrument in telegraphy which opens and closes the circuit in sending currents over the line for the transmission of signals: it consists essentially of a pivoted metal lever with a hard rubber finger tip by which it may be readily moved within limits, fixed by a spring adjusted by a set screw: the depression of the lever closes the circuit through the line and the release opens the circuit automatically by the action of the spring.

Telegraph Line.—The circuit of conducting wires comprised in a telegraph system.

Telegraph Line Faults.—May occur in telegraph lines from several causes: either from the breakage of the wires or conductors, or from the breakage of the insulators, thereby short-circuiting the current through the earth before it reaches the distant station, or, as in overhead wires, by two conducting wires touching each other. Various methods for testing the existence and position of faults are known to telegraph engineers; they depend upon accurate measurements of resistance or of capacity. Thus, if a telegraph cable parts in mid-ocean it is possible to calculate the distance from the shore end to the broken end by comparing the resistance that the cable is known to offer per mile with the resistance offered by the length up to the fault, and dividing the latter by the former.

Telegraph Line Adjuster.—An apparatus for overcoming the effects of escapes or grounds due to lack of proper adjustments on the part of telegraph operators at way stations on the line.

Telegraph Loop.—1. A continuous wire extending from a main office to a branch office and return.

2. In duplex or quadruplex telegraphy the two short wires used to connect a station with a branch office.

Telegraph Needle.—A small pointer employed with the needle system of telegraphy to indicate upon a dial by left and right deflections the signals of the code.

Telegraphone.—An electric apparatus designed to record the human voice, transmit it to indefinite distances and store it at the receiving end of the line for reproduction at will. Its construction is based upon the principle that a mass of tempered steel may be impressed with, and will retain magnetic fluxes varying in density and in sign in adjacent portions of its mass.

Telegraph Paper Winder.—An automatic device for winding up the paper tape of a printing telegraph ticker, or other similar registering apparatus, as fast as it is paid out by the receiving instrument.

Telegraph Pocket Relay.—A compact form of relay of small size for use in line testing.

Telegraph Poles.—Poles usually of wood, occasionally of iron, for carrying telegraph wires in overhead line construction.

Telegraph Register.—Any instrument for recording telegraph messages as received, by writing, printing, or embossing the signals upon a paper tape

Telegraph Repeater.—An apparatus employed in intermediate offices to receive a message from one wire and repeat it automatically into another, when circumstances do not permit of transmission over a continuous line; *a translator*.

Telegraph Sounder.—The receiving instrument employed in connection with the relay for enabling operators to read telegraph messages on receipt, by sound alone, as generally practiced in America. It consists essentially of an electromagnet whose armature, movable between fixed stops, makes a loud "click" upon the passage of the current.

Telegraph Stay Rods.—Metal rods used for stiffening telegraph poles; *guy rods*.

Telegraph Switchboard.—A switchboard in a telegraph office for making quick changes in the connections of wires, discs and batteries; it consists essentially of a series of vertical parallel brass straps on the front of the board, and a corresponding series of horizontal straps on the back, connection being made between the tw. by pin plugs fitting notched metal connecting discs.

Telegraph Time Service.—An automatic system of electric signals issued from a standard master clock to various points where it is required to preserve the precise time.

Telegraph Transmitter.—1 In automatic high speed telegraphy, an instrument, such as the *perforator*, for mechanically transmitting messages.

2. In police and fire signal telegraphy, a device for sending an alarm to a station by the motion of a lever.

Telegraph Valve.—A valve operated from some distance, by means of a cord passing round the hand wheel as a pulley. Same as a *telegraph cock*.

Telegraph Wire.—The electric conductor which constitutes a telegraph line.

Telegraphy.—The science and practice of the telegraph.

Tele-hydrobarometer.—An electrical instrument for recording at a distance the height of water in a reservoir.

Tele-indicator.—Any electrical device for indicating or recording at a distance the readings of a measuring instrument; a *telemeter*.

Tele-intensity of Projector.—The intensity of the light thrown by a searchlight projector upon a distant object.

Tele-manometer.—A recording manometer having its electric recording apparatus located at a distance from the instrument.

Tele-meteorograph.—A meteorograph having its recording apparatus located at some distance from the measuring instrument.

Telemeter.—An electrical device for indicating and recording at a distance the readings of any measuring instrument.

Telephone.—An instrument for the electrical transmission of articulate sound to long distances. One speaks into a transmitter, the sound vibrations of the voice causing a thin sheet metal or carbon disc to vibrate, causing electric waves to be set up in a steel magnet behind the disc. The electric waves are transmitted through the magnet winding to the conducting line, along the latter to the receiver, which is similar in construction to the transmitter, and, setting up corresponding vibrations in the disc of the receiver, make the sounds audible at the far end. The return current is through the earth.

Telephone Batteries.—The primary and secondary batteries employed in telephone work.

Telephone Booth.—A form of sound proof closet containing a telephone set to permit of private and quiet telephoning in public places; *a silence cabinet.*

Telephone Cable.—A cable composed of telephone lines which follow the same route, bunched together with proper insulation in order to simplify both overhead and underground line construction.

Telephone Call Bell.—A call bell connected with a magneto generator, forming the telephone calling apparatus by means of which a subscriber is summoned to the telephone by the exchange operator to answer a call.

Telephone Circuit.—The electric circuit comprised in a telephone system.

Telephone Cords.—Flexible cords terminating in metal plugs employed at a telephone switchboard for interconnecting subscribers.

Telephone Drop.—One of the annunciator drops of a telephone switchboard, which falls and attracts the operator's attention when a subscriber desires a connection.

Telephone Exchange.—A central telephone station connected with all lines in its section and with all other exchanges in its system; and provided with switchboards for making any desired connection between its subscribers or through other exchanges with any other line in the system.

Telephone Galvanometer.—A sensitive galvanometer used in connection with a Wheatstone bridge for testing telephone circuits.

Telephone Hook Switch.—An automatic arrangement of the telephone switch such that the switch lever is held down in contact with the terminal of the calling circuit by the weight of the receiver when not in use, and rises by a spring into contact with the talking circuit terminal when the receiver is lifted off.

Telephone Indicator.—Any indicator at a telephone switchboard, such as a drop, or lamp signal, for calling the attention of the operator to a subscriber's call.

Telephone Indicator Coil.—One or more electromagnetic coils designed for the operation of a switchboard drop.

Telephone Insulator.—A contrivance, usually of glass or porcelain, for supporting telephone wires and preventing escape of current.

Telephone Line.—The circuit of wires comprised in a telephone system.

Telephone Meter.—A device employed in a limited telephone service for recording the number of calls sent by a subscriber.

Telephone Operation.—Atmospheric sound waves strike the diaphragm of the telephone and cause it to vibrate.

The vibrating diaphragm produces a change in the magnetic field of the telephone.

The changes in the magnetic field induce currents in the wire coil of the telephone.

The induced currents are transmitted from the transmitter telephone through the line to the receiver telephone.

In the telephone receiver, the induction currents produce changes of intensity in the magnetic field.

In consequence of these changes in the magnetic field, the diaphragm of the receiver is thrown into vibration.

The vibrations of the diaphragm of the telephone receiver give rise to air waves, which are propagated to the tympanum of the ear.

Every time the human voice is used, vibrations of the air are produced, and the louder and higher the greater the number of vibrations· with each change of tone the diaphragm vibrates in sympathy.

Telephone Receiver.—The receiving instrument in a telephone circuit. It consists of a hard rubber tubular shell terminating in an ear piece and enclosing

the working parts. These parts are essentially: a horseshoe magnet carrying pole-pieces wound with fine wire and connected with binding posts at the terminal of the exterior circuit, and, just in front of the poles of the magnet, a diaphragm of thin varnished iron clamped between the ear-pieces and the body of the shell.

Telephone Relay, or Repeater.—A telephone repeater in which a microphone is acted upon by the receiver of the first line circuit so as to introduce a local circuit, which in turn acts inductively on the second line wire, and repeats the message; *a translator.*

Telephone Set.—The telephone equipment apart from the wiring and mounting, including the receiver, transmitter, induction coil, hook or other switch, call receiving and call sending apparatus.

Telephone Side Tone.—The sound heard in a receiver by the use of the transmitter of the same set.

Telephone Subscriber.—Any individual, firm, or institution that obtains telephone service through an exchange.

Telephone Subway.—In underground cable construction, a subway for accommodating telephone cables.

Telephone Switchboard.—In a telephone exchange, an apparatus by means of which any subscriber may be placed in communication with any other subscriber in the system; each line entering the exchange terminates in a spring jack, into which a plug attached to a flexible cord may be inserted by the operator for any desired connection.

Telephone Time-check.—An automatic device connected with a clock, employed in a telephone exchange to indicate to the operator the expiration of the time allowed a subscriber for the use of a trunk line.

Telephone Tinnitus.—A nervous trouble sometimes affecting the ears of a telephone operator because of too constant work at the telephone.

Telephone Transmitter.—The speaking end of a telephone instrument, consisting essentially of a mouth piece leading to a diaphragm which acts with variable pressure upon carbon granules held between conducting plates.

Telephone Wire.—Wires for telephone lines are made of copper or iron. Iron is much cheaper and has greater tensile strength than copper, but otherwise copper is far superior. The best wire is of hard drawn copper, cylindrical and of uniform diameter.

Telephony.—The science and practice of the telephone.

Telephote.—An instrument employing the photo-electric properties of selenium for the electric transmission of pictures; the *pherope.*

Tele-photography.—The photography of distant objects by means of a camera mounted in the eye piece of a telescope.

Telescope.—An optical instrument which magnifies the appearance of distant objects, causing them apparently to come nearer. It consists essentially of a tube containing the *objective*, a large converging lens or concave mirror (speculum) and a small *lens* or combination of lenses. The first forms an optical image of the object observed, and the latter magnifies the image.

Telescriptor.—The name of a special design of printing telegraph.

Teleseme.—An annunciator in a hotel office which indicates upon a dial the service required by a guest sending a call from his room.

Tele-thermograph.—An instrument for electrically recording the changes of a thermometer situated at some distance from the recording apparatus.

Tele-thermometer.—A thermometer which electrically registers its indications by means of a tele-thermograph at some distance from it.

Telltale.—A small wire carried on the outside of a cartridge fuse which melts when the enclosed fuse blows, and thus indicates that the fuse is burned out.

Telltale Board.—In automatic telephony, a group of incandescent lamps mounted upon a panel with a magnetic bell, so that when a fault or ground occurs on any line, the operator's attention is called by the ringing of the bell and the glowing of the lamp.

Telluric Magnetic Force.—A term sometimes applied to the force of the earth's magnetism.

Telluric Mines.—Explosive mines used in war for operations on land, as distinguished from mines used in naval warfare.

Telluride.—In chemistry, a compound of tellurium with a more positive element or radical; also called *telluret.*

Tellurium.—A white lustrous metal or metalloid, closely resembling sulphur and selenium in its chemical reactions; it has a specific gravity of 6.2, and melts at 845° Fahr.; it occurs native, but is more frequently found in combination.

Telpherage.—The automatic aerial transportation of material in a car suspended upon grooved wheels from a tightly drawn conducting cable, and propelled by electric motors actuated by a current from the supporting line.

Telpher Line.—The conductors forming the supporting circuit in a system of telpherage.

Telpher Locomotive.—The electric motor which produces the locomotion in a telpherage system.

Temper.—1. The state of hardness, or elastic condition imparted to steel by the processes of heating and quenching, after the preliminary hardening effected by bringing to a cherry red and suddenly cooling.

2. A classification of tool steel by the makers, depending almost entirely upon the percentage of carbon in the metal; as, *razor temper, saw-file temper, chisel temper.*

3. A mixture of two parts tin and one part copper, used by pewterers or by other metal mixers, to assist in the compounding of those alloys in which the percentage of copper is so small, that, if added alone, its high melting point would prohibit proper combination.

Temperature.—1. That which determines the heat or coldness of anything. A relative term denoting the heat of anything as compared with that of a standard, the temperature being measured by the number of graduations upon a thermometric scale.

2. The sensible heat in anything, the measurement of which is made by the thermometer.

3. A bright bar of iron, slowly heated in contact with air, assumes the following tints at annexed temperatures:

	Fahrenheit.
Cold iron at about..........	54°
Yellow at..................	437
Orange at..................	473
Red at.....................	509
Violet at..................	531
Indigo at..................	550
Blue at....................	559
Green at...................	630
Oxide Gray at..............	752

Temperature Alarm.—An electrical apparatus for giving an alarm when a certain temperature is passed.

Temperature and Volume of Gases.—The "second law of gases" called Charles' or Gay Lussac's law, states that: "At constant pressure the volume of a gas varies with the temperature, the increase being in proportion to the change of temperature and the volume of the gas at zero."

By actual experiment it has been ascertained that a gas increases in a ratio of 1-493d part of its volume at 32° Fahrenheit, with each additional degree added to its temperature. This places the "absolute zero," or the point at which a gas would assume its greatest possible density, at —461° Fahrenheit, or —273° Centigrade.

Temperature Calculations.—In temperature and pressure calculations for heat engines, it is customary to use absolute figures. Thus, the absolute temperature is the sum of the sensible thermometric temperature and the constant 461. This latter figure, which is more properly expressed as 460.66, represents the total number of degrees on the Fahrenheit scale from 32° below the freezing point of water to absolute zero of temperature, as calculated by the expansion ratio of gases. Thus, in calculating temperatures, one should count from absolute zero; instead of 64°, writing 525°, and instead of 32°, writing 493°, or, better 492.66°. The utility of this system lies in the fact that, as a gas has been found to expand by 1-273 of its original volume for each degree Centigrade, or by 1-461 for each degree Fahrenheit, of increased temperature, we have by the use of absolute figures an approximate expression for both increased heat and increased volume in the same number. The absolute zero is the point of theoretically complete stability of a gas.

Temperature Elevation.—The amount by which the heat of a body exceeds the temperature of the surrounding air.

Temperature Gradient.—A line indicating the rate of change which a body or quantity undergoes with variations of temperature.

Temperature of a Furnace Fire.—A method of finding the furnace heat is by submitting a small portion of a particular metal to the heat, thus:

Tin melts at	442° F.	
Lead " "	617° F.	
Zinc " "	700° F.	nearly.
Antimony melts at	810 to 1,150° F.	
Silver melts at	1.832 to 1,873° F.	
Cast Iron melts at	2,000° F.	nearly.
Steel melts at	2,500° F.	"
Wrought Iron melts at	2,700° F.	"
Hammered Iron melts at	2,900° F.	"

Temperature of Space.—The temperature that would be experienced outside of the earth's atmosphere by an object shaded from the sun; estimated at about 200° below zero, Fahr.

Temperature Regulating Switch.—In a system of car heating by electric coils, a switch by means of which any heater may be cut out of the circuit as required.

Temperature, Volume and Pressure Relations.—In conformity with the laws of permanent gases, the mutual relations of the temperature, volume and pressure of a gas in the cylinder of an engine vary according to the conditions which obtain at heating.

1. If the temperature of the gas is kept constant, an increase of volume results in a decrease of pressure (Boyle's Law).
2. If the pressure of the gas is kept constant, an increase of temperature results in an increase of volume. (Gay-Lussac's Law).
3. If the volume of the gas is kept constant, an increase of temperature results in an increase of pressure (Gay-Lussac's, Regnault's, and Joule's Laws).

Under these conditions, a gas acts according to the following modes of expansion or compression:

1. For expansion, when the pressure decreases as the volume increases, with a corresponding decrease in temperature due to the external work done by the gas in moving the piston.
2. For compression, when the pressure increases as the volume decreases, with an increase in the temperature due to the work spent upon the gas during the act of compression.

Tempering, Electric.—Bringing metal to a proper degree of hardness and elasticity by first raising it to a high temperature by electrical heat, and then rapidly cooling.

Tempering Tool Steel.—The treatment to which tool steel is subjected, to ensure the proper hardness and toughness for a desired purpose. After hardening, the tool is reheated, and as its temperature rises, colors appear upon its polished surface; these colors, due to films of oxides, pass from very pale yellow through brown to blue and purple, the steel being quenched in brine or cold water as the desired color appears. Microscopic investigation explains the phenomena attending the process. Steel consists of various manifestations of the same substances, rather than separate compounds.

Temporary Electromotive Forces.—Electromotive forces which cease after a brief duration.

Temporary Induced Charge.—A temporary electric charge produced in a body by induction.

Temporary Magnetism.–The magnetism of soft iron which disappears soon after the magnetizing force is removed.

Temporary Socket.—An incandescent lamp socket which is employed for temporary service

Tenacity.—The resistance which a body offers to a separation of its parts; it is directly proportional to the breaking weight, and inversely proportional to the area of cross section of the body.

Tensile Strength.—The capacity of a material to resist forces that tend to produce elongation. The tensile strength of a given material is the ultimate stress it can withstand before breaking.

Tension.—A term sometimes applied in electrical work to surface density, difference of potential and electromotive force.

Tension, Electric.—In an electric field, a stress along the lines of electric force producing an outward pressure on the external non-conducting medium.

Tension Ratchet.—A form of dynamometer used in overhead line construction to obtain the proper degree of tension in a wire; *a line dynamometer.*

Terella.—A small magnetized sphere of steel in which the distribution of magnetism resembles that of the earth; earthkin. *A globular magnet.*

Terminal.—A point at which a connection is made between an electrical apparatus and the external circuit.

Terminal Board.—A switchboard at the terminals of a dynamo.

Terminal Branch Cut Out.—A cut out for disconnecting a branch from the terminal of a main conductor.

Terminal Electromotive Force.—The electromotive force measured at the terminals of a dynamo.

Terminal Insulator.—A line insulator upon a terminal pole.

Terminal Pole.—In pole line construction, the last pole on the line, properly guyed against the heavy strain, and carrying the cable head, terminal box, or other terminal appliances.

Terminal Reflection.—A term sometimes applied to the radiation of electric waves from the terminal of a conductor left on open circuit.

Terminal Station.—The station situated at the end of a telegraph line.

Terminal Voltage.—The voltage at the terminals of an electric generator.

Terra-cotta Conduit.—A conduit of glazed earthenware.

Terrestrial Magnetic Induction.—Magnetic induction derived from terrestrial magnetism.

Terrestrial Magnetism.—The magnetism inherent in the earth; the determination of which depends upon the knowledge of the *magnetic elements*, viz., the *intensity*, the *declination*, and the *inclination*.

Tesla Coil.—A form of induction coil designed by Tesla for obtaining high potentials and frequencies: it consists of a primary of a few turns and a secondary of fine wire, both immersed in oil insulation; *a Tesla transformer.*

Tesla Discharge.—A high frequency disruptive discharge.

Tesla Frequencies.—The high frequencies which characterize Tesla discharges.

Tesla, Nikola.—Born 1857. An American electrical engineer of Austrian birth; inventor of the system of polyphase electric currents (1887), and distinguished for his experiments with electric oscillations.

Test Board.—In telegraph and telephone central offices, a board for permitting the ready introduction of testing instruments into any line entering the exchange.

Test Cell.—A voltaic cell for the operation of the "busy" test in connection with a multiple telephone switchboard.

Test Circuit.—The circuit of the "busy" test in connection with a multiple telephone switchboard.

Test Clamp or Clip.—In telephone wiring, a connection made between two wires so that they can be separated for the purpose of testing. Test clamps are also used to connect branch wires to main lines where a tap is to be made from the line, and at points where house wires are joined to main wires.

Test Clerk.—A person employed in testing the telephone or telegraph lines entering an exchange.

Test Clip.—A simple form of clamping device employed in telephone circuits for joining wires in such a way that they may be disconnected at that point for testing. Test clips are also used to connect branch wires and house wires to the main line wire.

Testing.—1. In electrical work, the making of tests to ascertain the electric condition of wires, circuits, or installations; especially for the determination of electric properties in the whole or any part of a system, the discovery of grounds, crosses, or any faults whatever, and the quantitative measurement of such conditions.

2. In mechanics, the act or process of determining the strength of materials, and their behavior under strains of various kinds; as, elongation, bending, crushing, etc.

3. In metallurgy, the operation of refining gold or silver in a test or cupel; cupellation.

Testing Bank.—A group of resistances for testing an electric circuit.

Testing Car.—A trolley car employed in making tests along the line of the railway.

Testing Engines.—The economy of steam engines as usually determined, relates to the weight of water consumed, to the quantity of coal used in making the steam, or to the number of heat units supplied; while in other forms of heat engine, it relates to the amount of gas, oil, or other fuel burned.

The heat consumption of internal combustion engines is found by ascertaining the total heat of combustion of the particular fuel used, as determined by a calorimeter test, and multiplying the result by the quantity of fuel consumed. In determining the total heat of combustion no deduction is made for the latent heat of the vapor of water in the products of combustion.

Testing Machine.—An application of the principles of the balance or steel yard for

testing the strength of materials. Pieces of approved and standard size and shapes, are firmly held in the jaws of the machine and the weights are applied through a system of compound levers working on knife edges. Modifications are made for compressive tests, or for proving cables.

Testing Magneto.—A powerful magneto-generator employed in electric testing.

Testing of Joints.—Testing the electric continuity of joints in a wire or cable.

Testing Pole.—An electrode employed in electro-therapeutics merely for the purpose of closing the circuit through the part of the body to be treated, as distinguished from the electrode which actually applies the treatment; an *indifferent electrode*.

Testing Post.—In underground cable construction, a hollow post sometimes set above ground, into which wires from the cables are led in order to facilitate testing.

Testing Room.—1. In a telephone exchange, a room back of the switchboard through which all the wires entering the exchange pass before reaching the switch-. board terminals.

2. Any room fitted with appliances for electrical testing.

Testing Set.—A portable instrument for locating faults, measuring resistances and similar purposes, in an electric system. A useful set consists of a Wheatstone bridge with decade resistances, a galvanometer and a battery of dry cells mounted together in a box.

Testing Switch.—In quadruplex telegraphy, a switch employed in balancing the resistance of the artificial line and the main line wire.

Testing Transformer.—A transformer employed in testing the electrical condition of a circuit.

Test Jacks.—Simple forms of spring jacks in connection with a telephone distributing board, for the introduction of testing instruments into the line side of the circuit.

Test Paper.—A paper prepared by dipping into a solution or decoction of a substance and drying; to be used to detect the presence of a substance whose presence causes a reaction, and a change in the color of the paper, as *blue litmus paper* changes to *red* by presence of an acid.

Test Plugs.—Plugs for insertion into test jacks, by means of which a testing apparatus may be introduced into a telephone circuit.

Test Ring.—1. Ringing up a subscriber from a central telephone exchange in order to determine whether the line is in proper working order.

2. The contact ring of a spring jack in a multiple telephone switchboard; *test thimble.*

Test Room.—A room is any electrical plant equipped with the necessary instruments and apparatus for making tests upon new machines, prior to their installation to determine whether they meet ratings and specifications, and upon the regular equipment to discover faults and unusual conditions.

Test Thimble.—In a multiple telephone switchboard, a thimble contact in front of a spring jack, which is connected to ground by the insertion of a plug, so that when an operator at another section of the board touches the test thimble of that line with the tip of the plug, a "busy" signal is given if the line be in use.

Test Wire.—1. In a multiple telephone switchboard, a wire connecting all the jacks of the same number at all the sections, so that when a line is in use at one section, the "busy" signal may be given at the corresponding jacks of the other sections.

2. In a metallic circuit, a name sometimes given to the return wire.

3. Any wire subjected to testing.

Tetrad Atom.—An atom having the valency, or combining power, of four units, *i. e., of four atoms of hydrogen.*

Tetrivalent.—In chemistry, a term applied to an atom having a valence, or combining capacity of four units, i. e., having a capacity to unite with *four atoms of hydrogen.*

Tetrode Working.—In synchronous multiplex telegraphy, the simultaneous transmission of four messages over the same wire.

Thallium.—A rare, bluish-white metal, widely distributed, but found in small

quantities; as, in certain kinds of iron and copper pyrites, in some minerals and in many mineral springs. It has a specific gravity of 11.9, and melts at 561° F. It resembles lead, and is so soft that it can be scratched with the finger nail. Thallium has been used in glass manufacture, producing a glass of extraordinary brilliancy and high refractive power.

Theatrophone.—An automatic slot machine by which telephone communication may be had with a theater or opera, and the performance heard from a distance.

Theoretical Efficiency.—In mechanics, the quality of producing an effect, or power or agency, terminating in theory or speculation.

Theoretical Magnet.—A magnet existing only in theory for the sake of discussion and assumed to have infinite length and thinness, and to be uniformly magnetized throughout.

Theoretical Mechanics.—The science dealing with forces and their effects upon matter; differing from *applied mechanics*, in that the latter science deals with actual examples of mechanisms and structures.

Theory of Heat Engines.—Both steam and gas engines are forms of heat motor; since both operate by means of the expansive energy of gases. which have been subjected to the action of heat. A permanent gas, or the vapor from a liquid or solid substance, when exposed to heat tends to expand, and, in expanding, exerts an active pressure in all directions. Thus, if a gas, or a readily volatised liquid, like water or alcohol, contained in a corked vessel, be exposed to heat, the expansion will be exhibited in the expulsion of the cork. In this fact is demonstrated the principle, on which all forms of heat engine operate: that heat may be transformed into mechanical energy through its effects on liquids and gases, promoting the change from fluid to gaseous state and then increasing the volume of the gas. No state of matter is entirely permanent, and, as a general rule, the absorption of a sufficient quantity of heat results in liquefying a solid, and in vaporizing a liquid. Gases subjected to heat, either when ignited, as with inflammable gases, or merely heated as with separated steam, tend to assume greater volumes so long as the temperature is not allowed to fall. On the other hand, modern science has succeeded in producing liquid air and liquid carbonic acid gas by the combination of extremely high pressures and extremely low temperatures. It is sufficient to say that no pressure has yet been found sufficiently high to liquefy air, without the cooperation of a temperature commensurately low. Conversely, also, no known degree of cold can produce this effect, apart from a high pressure acting at the same time.

Therapeutic Electrization.—The treatment of disease by electricity; *electro-therapeutics*.

Therm.—The unit of heat in the C. G. S. system, equivalent to the amount of heat necessary to raise the temperature of a gram of water from 0° to 1° Centigrade; the *calorie*.

Thermæsthesiometer.—In electro-therapeutics, an instrument for determining the degree of sensitiveness of different parts of the body to temperature variations.

Thermal.—Relating to heat.

Thermal Absorption.—The absorption of heat rays in passing through a solid or liquid.

Thermal Arrester.—A protective device for telephone apparatus, by means of which "sneak" currents are arrested by cutting an instrument out of circuit when a stray current exceeds a predetermined limit; *a heat coil*.

Thermal or Thermic Balance.—An instrument of great sensitiveness, consisting essentially of a Wheatstone bridge having two strips of blackened platinum foil inserted in the arms, for measuring minute quantities of heat energy by the changes of electrical resistance produced in a metallic conductor by variations of temperature; *a bolometer*.

Thermal Capacity.—The quotient of the heat received by the rise of temperature produced in a body.

Thermal Circuit Closer.—A device for closing a circuit by the action of heat.

Thermal Coil.—In a rheostat, a coil having a high temperature coefficient introduced for the purpose of indicating the amount of heat generated by the resistance.

Thermal Current.—A flow of heat in a conducting body from the region of the higher temperature to the region of lower.

Thermal Current Strength.—The amount of heat flowing through unit cross section of a conducting body per second of time.

Thermal Efficiency.—1. No heat engine can convert into mechanical energy more than a small fraction of the heat supplied to it, the greater portion being necessarily lost in various ways; in overcoming the molecular resistance of the working sub-

stance to changes of form; in overcoming the friction of the working parts of the mechanism; and by rejection, so that the efficiency becomes the ratio:

$$\frac{\textit{Heat converted into work}}{\textit{Heat absorbed by the working substance}},$$

which is a fraction always much less than unity, and represents the thermal efficiency of an engine operating under actual working conditions.

2. The ratio of the heat equivalent of the work done on the piston of a steam engine per unit of time, to the heat supplied to the engine.

Thermal Efficiency Ratio.—The standard expression for efficiency is the thermal efficiency ratio or the proportion which the heat equivalent of the power developed bears to the total amount of heat actually consumed, as determined by test. In this case, one horse power per hour represents 1,980,000 foot pounds of energy, and this divided by 778 foot pounds, the mechanical equivalent of one British Thermal Unit, gives 2,545 for the numerator of the expression,

$$\frac{2{,}545}{\text{B. T. U. per H. P. per hour}},$$

which expresses the thermal efficiency ratio.

Thermal Equivalent of Work.—The amount of heat which can be produced by a given amount of mechanical work.

Thermal Resistance.—The opposition made by a body to the flow of heat through it.

Thermal Unit.—A measure of mechanical work, found by experiment to be equal to the energy necessary to raise one pound of water 1° Fahr., in temperature Known as the British thermal unit or B. T. U.

Thermit.—A granular mixture of aluminum and iron oxide, in exact chemical proportions, so that a perfect union may ensue on combustion, and nothing but alumina and pure iron remain behind as products.

Thermit Welding.—A chemical process whereby internal local heat may be obtained, to fuse together iron and steel parts of considerable size. The temperature of ignition is a little less than that of molten steel, and below this it will not ignite. It is perfectly safe, therefore, against a red hot poker, or even molten cast iron; and may be thrown into an ordinary fire without injury. It would be ignited, however, by molten steel or, indeed, by any other method which would produce the temperature of ignition, however small the area of attack. In practice, a special ignition powder is provided, which may be started by a lucifer match thus causing a local heat of sufficient intensity to ignite the thermit, whose ingredients now combine and cause the enormous temperature of 5400° F. by their combustion. The iron being freed, the aluminum goes to form with the oxygen a slag of alumina, which appears as thin, dark red flakes of what may be called emery, ruby, or sapphire; both slag and iron remaining fluid at the high temperature. It is this immense evolution of heat that serves for the welding of two pieces of iron or steel, being thus analogous to electric welding, or to any other process where a sudden supply of intense heat is desired.

Thermo-barometer.—An instrument for measuring the height of mountains, consisting essentially of a sensitive thermometer by which the temperature of the boiling point of water at a given elevation is determined; *a hypsometer.*

Thermo-battery.—A name sometimes given to the *thermopile,* being a number of thermo-electric couples or thermo-cells connected in series in one circuit so that when alternate junctions are oppositely heated, the various E. M. F's act in the same direction and increase the current in proportion to the number of pairs of junctions in the "battery."

Thermo-cell.—A term sometimes applied to a *thermo-electric couple.* It is a junction of two dissimilar metals, which, when heated, produces a flow of electric current. A couple of this kind composed of platinum and an alloy of platinum and rhodium is the element used in thermo-electric pyrometers for measuring high temperatures.

Thermo-chemical Cell.—A voltaic cell which generates an electric current by means of chemical action induced by heat.

Thermo-chemistry.—That branch of chemistry which treats of the manifestations of heat which are associated with chemical action.

Thermochrosy.—The property of radiant heat which permits of its being analyzed into component rays of different refrangibilities, like light rays; *heat color.*

Thermodynamics.—The branch of the theory of heat that treats of the relations between heat and mechanical work, especially as acting in a heat engine; as, the steam engine. This term is made from two Greek words, which signify, respectively, *heat* and *power.*

The first two laws of thermodynamics are as follows: (1) In the conversion of heat into mechanical energy, one unit of heat is lost for every 778 foot pounds of energy obtained; and conversely, in the production of heat by mechanical means, one unit of heat is obtained from every 778 foot pounds of energy expended. (Joule.) (2) It is impossible for a self-acting engine to convey heat from one body to another at a higher temperature without external aid. (Clausius.)

Thermo-electric Alarm.—An electrical apparatus for sounding an alarm when the temperature passes a certain danger point.

Thermo-electric Battery or Generator.—A term sometimes applied to the *thermopile*, a number of thermo-electric couples joined in series in one circuit so that by differently heating alternate junctions the current generated is increased in proportion to the number of pairs of junctions.

Thermo-electric Cell or Pair.—A *thermo-electric couple.* A junction of two dissimilar metals, such that if the junction be heated, a current of electricity will be set up in the circuit formed by the two conductors.

Thermo-electric Couple.—A pair of dissimilar metal strips or wires joined at their ends, each junction being brought to a different temperature so that an electric current is obtained through the circuit thus formed.

Thermo-electric Current.—A current of electricity obtained by unequally heating the junctions of a thermo-electric couple.

Thermo-electric Detector.—In wireless telegraphy, a form of detector which measures the energy of the oscillations instead of the voltage or current as in coherers or magnetic detectors. They are based on the rate at which heat is produced in a short, fine wire through which oscillatory currents of high frequency pass. There are several types of thermo-electric detectors; (a) those which depend upon the temperature variation of the resistance of the wire in which the energy is converted into heat; (b) those in which the heat from the wire acts on a thermo-electric junction in the circuit of a galvanometer; (c) those which utilize the expansion of the conductor; and (d) in which the heating of the wire is measured by the expansion of the air in the vessel which encloses the wire.

Thermo-electric Diagram.—A diagram for illustrating the thermo-electric relations of various metals, in which the abscissas represent the absolute temperatures, and the ordinates the increase of electromotive force per degree rise of temperature with reference to lead as a standard metal.

Thermo-electric Effect.—The effect of producing an electric current by unequally heating the junctions of dissimilar metals in a thermo-electric couple.

Thermo-electric Element.—Any metal joined with another to form a thermo-electric couple.

Thermo-electric Force.—The difference of potential developed by the union of two unlike metals joined in a closed circuit and heated at one of the junctions, causing an electric current to flow in the circuit.

Thermo-electric Inversion.—A phenomenon which occurs when the temperature of a thermo-electric junction is gradually raised to a high degree; the current originally flowing in one direction ceases altogether when the neutral point of temperature is reached, and beyond that is reversed in direction.

Thermo-electricity.—That branch of the science of electricity which treats of electric currents generated by heat applied to the junction of dissimilar metals.

Thermo-electric Junction.—The point at which the two metals of a thermo-electric couple are joined; *a thermo-junction.*

Thermo-electric Laws.—The two chief laws of thermo-electricity may be stated as follows: (a) The electromotive force developed by a heated junction depends on the metals used and is independent of the size. (b) If a complete circuit be made of two metals, joined at the extremities, and one junction be heated while the other is kept cold, the electromotive force generated is proportional to the *difference* between the temperatures of the hot and cold junctions within certain limits.

Thermo-electric Multiplier.—A sensitive instrument consisting of the combination of a galvanometer with a thermopile for measuring minute differences of temperature.

Thermo-electric Neutral Point.—In gradually increasing the temperature of a thermo-electric junction, a point at which the current ceases just before inversion takes place.

Thermo-electric Pile.—A *thermopile.* A number of thermo-electric couples joined in series in one circuit, so that if one set of

Thermo-electric Power.—The coefficient by which the difference of temperature of the junctions of a thermo-electric couple must be multiplied to give the potential difference in micro-volts.

alternate junctions is exposed to one temperature, and the other set to another temperature, the electromotive forces of all the junctions will act in the same direction, and the total E. M. F. will be proportional to the number of pairs of junctions in the series.

Thermo-electric Pyrometer.—An apparatus for measuring high temperatures, depending for its action upon the principle of the thermo-electric couple. By heating the junction of two dissimilar metals an electromotive force will be set up which will deflect a galvanometer joined in series in the circuit. A well known type consists of a junction of platinum wire and a wire composed of an alloy of platinum and rhodium in a fire-clay tube closed at one end, and an opposite junction of the wires kept at the temperature of the atmosphere and joined to a galvanometer. Such a junction can measure temperatures up to 3227° F., the melting point of platinum.

Thermo-electric Series.—A list of metals arranged in order such that each metal is electrically positive to the metals following it in the series.

Thermo-electromotive Force.—A potential difference created by the unequal heating of the junctions of a thermo-electric couple.

Thermo-element.—One of the two dissimilar metals which form a thermo-electric couple.

Thermo-galvanometer.—A pair of instruments devised by Duddell for measuring the current delivered by a high frequency alternator. They are capable of registering through a very great range from a micro-ampere to many amperes. The operating principle is that the heat generated by the current in a wire acts upon a thermo-electric junction which forms a part of a galvanometer circuit. This device may be used as a detector in wireless telegraphy over considerable distances.

Thermograph.—A standard type of self-registering thermometer.

Thermo-junction.—A *thermo-electric junction*; the uniting of two unlike metals in a conducting circuit so that, by heating one of the points of joining, an electric current will be set up in the circuit.

Thermolysis.—The decomposition of a compound into its parts by heat; *dissociation by heat.*

Thermo-magnetism.—The effect of heat upon a magnetized substance in developing new magnetic properties or in altering magnetic conditions; *pyromagnetism.*

Thermometer, Electric.—The electric *pyrometer*, an instrument for the accurate measurement of temperatures which lie beyond the range of the ordinary mercury thermometer. There are two classes of pyrometers: (*a*) those in which the heat is applied direct; and (*b*) those in which the image of the glowing body is thrown upon the thermometer by a lens or mirror.

Thermometric Heat.—The sensitive heat possessed by a body, as distinguished from *radiant* heat.

Thermometric Resistance Coil.—A coil of known resistance at a given temperature, used to indicate changes, or degrees of temperature, by the alterations in its power of resistance.

Thermometric Scale.—The graduated scale to which thermometers are referred. The common scale is Fahrenheit's, in which zero is the temperature of a mixture of salt and snow, 32° that of melting ice, and 212° that of boiling water. For temperatures between 212° and 400° Fahr., comparisons should be made with the temperatures given in Regnault's Steam Tables, by placing the thermometer in a well of mercury surrounded by saturated steam under sufficient pressure to give the desired temperature. The Celsius and Réaumur scales run from the temperature of melting ice to that of boiling water, the former having 100 graduations and the latter 80, hence, the Celsius is called the Centigrade thermometer.

Thermometry.—The science and practice of measuring temperature.

Thermo-pair.—A thermo-electric couple or pair. If a junction of two dissimilar metals forming a part of a closed circuit be heated, the heat energy will be transformed into electrical energy, and a current will flow around the circuit. This phenomenon is called the *Seebeck effect* from the man who discovered thermo-electricity.

Thermophone.—A variety of receiving telephone in which sounds are produced by changes in the circuit caused by temperature variation.

Thermopile.—A group of thermo-electric couples connected in series so that one set of junctions can be heated while the others are kept cool; the resultant electromotive force being considerable, as from a voltaic cell; *a thermo-electric battery.*

Thermopile Galvanometer.—A galvanometer employed in connection with a thermopile to measure minute variations in temperature.

Thermoscope.—An instrument for indicating differences of temperature at two neighboring places without measuring the amount.

Thermostat.—An automatic device by which an electric circuit is closed when a given temperature is reached: it may act so as to give an alarm of fire, or to regulate temperature by controlling the source of heat or ventilation.

Thermostatic Alarm.—An alarm given by the automatic closing of an electric circuit by means of a thermostat.

Thermostatic Regulation.—The regulation of temperature by a thermostat employed to control the source of heat or ventilation.

Thermo-telephone.—1. A telephone receiver in which the diaphragm is actuated by the effects of changes of temperature upon a fine wire attached to it, through which the currents pass.

2. A telephone transmitter in which the heating effect of the current changes the resistance of a wire which, acting through an induction coil, sends currents out to the line.

Thimble Brush.—A form of brush suitable for cleaning the interior of thimbles and similar surfaces preparatory to electroplating.

Thinning of Boiler Plates.—When the tube sheet and tube ends near the sheet become coated with scale or the tubes become overheated, the metal wastes away, thus resulting in thinning. This can usually be detected by examination, sounding with a round-nosed hammer, or drilling small holes in suspected parts not otherwise accessible for examination.

Third Rail.—A bar conductor of electricity, properly insulated, running parallel with the railway track, and at the same level as the rails, transmitting power from a central point to the motors of the train.

Third Rail System.—A system of electric traction employing a third rail to convey the current to the motors: this rail is carried on insulators between the rails or along the side of the tracks, the contact being made by cast iron rubbing shoes carried on insulated spring supports.

Thompson, Elihu.—Born 1853. An American electrical engineer; inventor (1886) of electric welding, and high-frequency electrical apparatus; contributor to the general development of the science of electricity.

Thompson, Silvanus Phillips.—Born 1851. An English physicist who has contributed largely to the spread of the knowledge of electrical science.

Thomson.—A name proposed for the *mho*, the unit of electrical conductance.

Thomson Effect.—The tendency to increase or decrease the difference of temperatures when an electric current flows through an unequally heated metal; in *copper* the current transfers heat from the hotter to the cooler parts, tending to equalize the temperatures; in *iron* the current transfers heat from the cooler to the hotter parts, tending to increase the difference in temperature; in *lead* the effect does not exist.

Thomson-Houston Dynamo.—A special form of arc lighting machine having an open coil armature, special commutator, and an automatic regulation by the shifting of the brushes.

Thorium.—A rare white metal, specific gravity 11, which has not been melted. Its compounds, as in the ordinary Welsbach mantle, are radio-active, though doubt exists as to the radio-activity of thorium itself.

Three Bladed Switch.—A knife switch having three blades for the simultaneous control of three circuits.

Three Cornered Repeater.—In telegraphy, an automatic repeater for repeating a message from one wire into two or more other wires.

Three Cylinder Engines.—In steam engineering, these may be divided into two main classes, those in which the cylinders are placed at an angle of 120° to each other, and those in which they are ranged side by side. The pistons of three cylinder engines being in equilibrium, there is no balancing of reciprocating parts required, and they can be run at a much higher speed and steadier than engines of the ordinary reciprocating

type. Hence, they are employed for driving dynamos, centrifugal pumps, circulating pumps, and high speed machinery, generally. The foregoing relates to engines having three high pressure cylinders of equal size, and does not apply to a three cylinder triple expansion engine with respect to the balancing features.

Three Filament Incandescent Lamp. —An incandescent lamp designed for use with three phase currents, having three filaments joined at their inner ends and connected to three leading in wires from the three wires of the circuit.

Three Part Commutator.—A commutator composed of three segments.

Three Phase Alternator.—An alternating current dynamo which produces three single phase alternating E. M. Fs. differing in phase from each other by 120°. This phase difference is due to the relative position of the three windings upon the armature.

Three Phase Armature.—An armature so wound as to produce three phase currents; *a triphase armature.*

Three Phase Armature Winding.—
1. The *star* winding, represented by the symbol Y, in which one end of each coil is connected to the main leads, the free ends of the coils being connected together.
2. The *triangle* or *mesh* winding, represented by the symbol Δ, in which the coils are connected so as to form a triangle, with the three main leads connected to the corners of the triangle.

Three Phase Circuit.—An electric circuit for transmitting three phase currents; *a triphase circuit.*

Three Phase Current.—An alternating electric current in which three electromotive forces are invariably 120° apart. Three phase currents are largely used in power transmission systems.

Three Phase Meter.—An electric meter employed in a three phase system.

Three Phase Motor.—A motor driven by three phase currents; *a triphase motor.*

Three Phaser.—A dynamo generating three phase alternating currents; *a three phase alternator, dynamo,* or *generator.*

Three Phase Rotary Converter.—A dynamo for generating three phase alternating currents as well as direct currents.

Three Phase Rotary Field.—A rotary magnetic field created by three phase currents.

Three Phase System.—An alternating current system transmitting three alternating currents of the same frequency, but differing in phase by one-third of a period; *a triphase system.*

Three Phase Transformer.—A group of three single phase transformers employed in the transformation of pressure in a three phase system.

Three Phase Two Phase Transformer.—A transformer system for converting three phase into two phase currents.

Three Phase Working.—The operation of a three phase system.

Three Point Switch.—A switch provided with three contacts; *a three way switch.*

Three Throw Crank.—A shaft having three cranks forged upon it at angles of 120° for driving three valves, or buckets or pistons, and used chiefly for pumps. The cranks being so arranged, are in equilibrium in any position, and can be run smoothly at a high rate of speed and also started in any position. This sequence of cranks is generally used with triple expansion engines, producing an almost uniform torque; the order of turning being, high pressure crank leading, and intermediate and low pressure cranks, respectively, following.

Threeway Cock.—A cock having three branches or passages for the delivery of the fluid passing through it.

Threeway Frog.—A frog inserted in a trolley wire at a point where two branches turn off from the main line.

Threeway Plug.—In a multiple telephone switchboard, a plug provided with three contacts, viz., the tip, the sleeve and the ring,

Threeway Switch.—A form of switch by means of which a circuit may be closed through three contacts; a three point switch.

Threeway Trolley Frog.—A frog suspended in a trolley line for properly guiding the trolley wheel at a point where the track splits into three branches.

Threeway Trolley Switch.—In an electric railroad, a switch at a point in the track where two branches join the main line; *a three point switch.*

Three Wire Circuit.—The circuit employed in a three wire system of electrical distribution.

Three Wire Distributing Board.—A distributing board employed in connection with a three wire system.

Three Wire Mains.—The *plus* and *minus* mains in a three wire system.

Three Wire Meter.—A meter designed to measure electrical supply in a three wire system of distribution.

Three Wire Multiple Switchboard.—A telephone switchboard, known as the "branch terminal multiple," in which three distinct line circuits enter each section of the board.

Three Wire Switchboard.—Any switch board employed in a three wire system.

Three Wire System.—A system of electrical distribution, especially in incandescent lighting, employing two dynamos joined in series and connected at their free terminals to the positive and negative mains, respectively, between which a neutral or balance wire, usually smaller than the mains, is introduced and joined to the junction of the dynamos.

Three Wire Telephone System.—A branch terminal multiple system in which three wires are provided for each line extending through the multiple.

Three Wire Two Phase Circuit.—A transmission circuit for two phase currents employing, instead of four wires, three wires, one of which acts as the common return for the other two.

Three Wire Working.—Electric distribution by the three wire system.

Throttling Governor.—A controlling mechanism applied to a steam or gas engine, which operates by varying the rate of supply of working fluid supplied to the machine. In steam engines, a valve contracts the supply passage according to the demand; with gas engines, similar valves vary either the amount of gas admitted or the quantity of mixture supplied; the first being known as *qualitative*, the second as *quantitative* governing.

Through Circuit.—A telegraph or telephone circuit completed to a distant station for direct communication.

Through Line.—In telegraphy, a line for direct communication between terminal stations, as distinguished from a *way line.*

Through Traffic.—In telegraphy, direct communication between terminal stations as distinguished from *way traffic.*

Throw Back Indicator.—An annunciator provided with electrically self-restoring drops.

Throw of Needle.—An impulse given to the needle of a ballistic galvanometer by the passage of electric discharge through the coils before the inertia of the needle is overcome.

Throw Over Reversing Switch.—A double throw switch for reversing a current.

Throw Over Starting Switch.—A double throw switch for starting a motor.

Throw Over Switch.—A knife switch which may be thrown over into either of two opposite sets of contacts; *a double throw switch.*

Thumb Cock Electric Burner.—A gas burner which is ignited by a wipe spark produced by the turn of the thumb cock.

Thumb Nut.—A nut fitted with projecting wings, so that it may be loosened or tightened by hand. *A wing nut.*

Thumb Screw.—A screw furnished with a large winged head, in line with its axis, so that it may be manipulated with thumb and finger.

Thunder.—The report which follows a discharge of lightning, caused probably by the heat of the air in the region of the flash producing sudden expansion and compression, followed by a swift burst of air into the rarefied space.

Thunder Storm.—A rain storm, during which the electricity carried by the clouds passes to the earth in disruptive discharges in the form of lightning, accompanied by thunder.

Ticker.—A printing telegraph employed for reporting stock quotations, race-track information, etc. The message is printed out in full in the ordinary alphabet upon a strip of paper. Toothed wheels with letters and numerals upon their peripheries operate under control of an electromagnet and signaling key. When the key is depressed at the sending station the wheels of the receiving machine cease to rotate, and an electromagnet presses the paper tape against the tooth that stops opposite. It is usually called *stock ticker.*

Ticket Operator.—In a telephone exchange, an operator who keeps a record of the calls on suitable tickets.

Tie Bars.—In railway track construction, flat iron bars extending at right angles between the rails at intervals of six feet, to prevent spreading of the track.

Tie Feeder.—A sub-feeder for connecting a trolley wire with the feeder proper.

Tie Line.—An electric conductor employed for the sole purpose of conveying current between two points in a system in order to equalize pressures.

Tie Wire.—In pole line construction, a piece of wire, usually about sixteen inches in length, for tying the line wire to an insulator.

Tightening Pulley.—One which rests against the belt in order to tighten it, to increase its frictional adhesion to the pulleys over which it runs.

Timber.—A single piece or squared stick of wood for building, or already framed; the larger pieces or sticks of wood, forming the framework of a house, ship or other structure, in distinction from the covering or *boarding*; the material for any structure; lumber dressed for use.

Timber Measurement.—Timber is measured in various ways. By the *superficial foot,* reckoned as one inch thick, as in boards; by the *cubic foot,* as in logs or beams; by the *load,* as in wholesale dealing; by the *hundred,* as in deals and battens.

Timber Preservative.—A solution injected into the pores of wood to prevent rot and preserve it from the attacks of insects. In the "Ferrell" process, sulphate and chloride of aluminum are employed; various metallic salts, such as bichloride of mercury, sulphate of copper and zinc chloride have been also tried. The best of all preservatives is *creosote.* Seasoned timber is placed in a long, closed, wrought iron cylinder, from which the air is exhausted; creosote at 120° F. is then pumped in until a pressure of 170 lbs. per sq. inch is attained. Soft wood will absorb a maximum of 12 lbs. creosote per cubic foot, very hard woods not more than three lbs. Timber must always be well seasoned before painting, as the coat of paint tends to imprison moisture, rendering the wood liable to rot.

Timbre.—The quality of sound dependent upon the form of the sound wave. It does not depend upon the frequency or rate of vibration, as does the *pitch,* nor upon the amplitude of the wave, like the *loudness,* but upon the number of overtones superimposed on the fundamental tone, and their relative intensities.

Time Ball.—A ball suspended from a staff in a conspicuous position, which drops at the exact hour of noon by the electrical action of a standard clock, thereby indicating the exact time to the community.

Time Constant.—In an electric circuit, the time (in seconds) which must elapse from the moment the circuit is completed before the current attains .634, or nearly two-thirds, of its full strength; it is equal to the self-inductance (in henries) divided by the resistance (in ohms) of the circuit.

Time Cut Out.—A cut out which automatically removes an apparatus from a circuit at the expiration of a given time, especially for cutting out a storage battery when fully charged.

Time Detector.—An electrical apparatus for recording the time a person, as a night watchman, arrives at a point in his rounds and makes or breaks the circuit which operates the register.

Time Electric Meter.—A meter for measuring the length of time during which an electric current of constant strength is supplied to a consumer.

Time Fall of Secondary Cell.—The fall of electromotive force delivered by a secondary or storage cell as it becomes spent.

Time Gun.—A signal gun which is electrically connected with a standard clock, so that it is discharged at a given time, as at sunrise or sunset.

Time Lag of Magnetization.—A peculiar quality of an iron core, such as an arma-

ture core undergoing rapid reversals of magnetism, by which there occurs an expenditure of energy which is converted into heat. This loss of energy is due to the work required to change the position of the molecules of the iron, and takes place both in the process of magnetizing and demagnetizing; the magnetism in each case lagging behind the force; *hysteresis.*

Time Illumination.—The quantity of light furnished in a given time.

Time Limit Relay.—A relay for operating a circuit breaker after a predetermined time. It is provided with a *time lag* device which retards its action for a time, depending on the extent of the overload.

Time of Vibration.—In vibratory or wave motion, the time it takes to complete a single cycle of vibration.

Timer.—A device forming a part of the jump spark ignition system of internal combustion engines. It consists of a revolving switch operated by the engine, and has a contact point for each cylinder which the switch in revolving makes and breaks the primary circuit at such times as the secondary current is required for the production of the spark.

Time Relay.—In a stock ticker system, a relay for the purpose of delaying for an instant the rotation of the type-wheel until the letter or figure is correctly printed upon the tape.

Time Rise.—The rise of electromotive force experienced by a secondary or storage cell during the process of charging.

Time Signal.—1. A telegraphic signal given from an observatory to distant points, electrically connected therewith, to indicate standard time at noon or some other convenient hour, thus ensuring correct and uniform time at all points.

2. A signal given by time ball, cannon, etc., to indicate a certain known hour, generally noon, or six P. M., thus giving a standard time.

Time Switch.—A self-acting switch controlled by a clock so that a circuit may be opened or closed automatically at a given time.

Time Telegraphy.—A system of telegraphy by which the exact time is simultaneously indicated at various points by electric signals from a standard clock.

Timing.—1. In mechanics, the regulation of the parts of a machine so that all the motions shall take place in due time and place.

2. The system or process by means of which the moment of ignition is regulated, in an internal combustion engine.

3. The arrangement of the ignition period, more especially in a multi-cylinder engine; an analogous expression to *valve setting* in regard to a steam engine.

Timing Lever.—A lever fitted to motor vehicles by means of which the time of ignition is advanced or retarded, or as it is frequently termed, the *spark lever*, because it controls the timing of the electric spark.

Tin.—1. In mechanics, thin plates of iron covered with tin.

2. In chemistry, one of the few *elementary substances* of which the world is composed. It is found as an oxide, and reduced into a malleable, fusible, soft, white, lustrous metal, and used for numerous purposes.

Tin has a specific gravity of 7.29, melts at 450° Fahr.; is very malleable, being capable of being beaten and rolled into *tin foil*, but becomes brittle, at 390° F. It forms part of many important alloys; with copper to form *bronze* or *gun metal;* with antimony to constitute Britannia metal; with varying proportions of lead, to make *pewter* and *solder;* sheet iron or steel is coated with it to form *tin plate*. Cast refined tin in ingots is known as *block tin;* when heated to the temperature at which it becomes brittle, it constitutes *grain tin*.

Tin Bath.—1. In plating by the dipping process, the bath of molten tin into which the sheet of iron is immersed.

2. In electroplating with tin, the solution of tin salt in which the object to be coated is suspended as the cathode.

Tin Chloride.—Stannous chloride, or tin salt. A white crystalline salt readily soluble in water. On fusing it forms a solid opaque mass of a pale yellow color. In electroplating, it serves in the preparation of brass, bronze and tin baths.

Tin Foil.—Tin or some alloy resembling tin rolled into very thin sheets. Tin foil is largely used in making condensers and for coating Leyden jars.

Tinned Cable.—A cable having a coating of tin outside of the lead sheath to protect the lead from chemical action in underground work.

Tin Plate.—Thin sheets of soft iron or mild steel which have been coated with

tin by dipping in a bath of melted tin which serves to protect the iron from rust and gives it a bright surface. After preliminary *scaling*, by dilute hydrochloric acid, heating, hammering and rolling, the plates are *pickled*, first in acidulated bran, then in a solution of sulphuric acid. This is followed by a clean water bath and scouring with sand and hemp. A number of plates, previously greased, are plunged for an hour or more in a bath of molten tin, whose surface is protected against oxidation by a thick layer of tallow. Upon removal, after draining in an iron rack, the sheets are placed in a second bath from which they are taken out singly, swept with a hemp brush, and dipped a third time to remove the brush marks. Next, they are dipped into melted tallow, and allowed to drain once more. Following this, the plates are dipped into a pot containing a little tin, which melts off the *list* or rim of tin along either end; the grease is removed by rubbing with dry bran; the plates are finally sorted and boxed for world-wide consumption.

Tin Plating.—The coating of iron or steel with tin to protect it from oxidization and to provide a bright surface. The iron is first cleaned by *pickling* and then dipped into a bath of melted tin.

Titanium Lamp.—A form of incandescent lamp having a filament composed of the carbide of the metal titanium prepared in an electric furnace. The filament is strong and elastic and much shorter than that of carbon. Tests show initial watts per candle of 2 53 and final 3.35 at the end of 1000 hours.

T. P. M.—Abbreviation for *turns per minute*.

Tobin Bronze.—A non-corrosive bronze of great tensile strength, capable of being forged at a dark red heat; much used in marine work. It consists of copper 59. parts, tin 2.16, zinc 38.40, iron .11 and lead .31.

Toe of Grapnel.—One of the flukes or claws of a grapnel.

Toepler Influence Machine.—A type of static electric machine consisting of two varnished glass discs, one fixed and the other rotating before it, and carrying metallic buttons mounted on tin foil upon its faces, from which the charges are drawn off by collecting combs; a modified form of the *Holtz influence machine*.

Toggle Joint.—An elbow joint; a mechanism common in many forms of presses and in stone crushers; by its action it gives an enormous mechanical advantage. It consists of two rods or plates *hinged* together and employed to transmit a varying force by side pressure on the hinge, which is called the *knuckle* or knee from its resemblance to the knee of a man.

Toll Lines.—In telephone circuits, the term, "toll line," is used to designate a trunk line between exchanges, which may have a number of private telephones bridged in its length, or where a party line telephone circuit has its terminals in a central exchange switchboard. This designation is said to be derived from the fact that each separate telephoner on the circuit is charged for every occasion on which he uses the line, just as formerly persons driving on country roads paid a designated fee, at the various toll gates they might pass, for the maintenance and repair of the highway. Also, where the term is applied to a trunk line, as stated above, it is proper from the fact that such lines, frequently leading to exchanges conducted by other companies, involve an additional "toll," or charge, to the subscribers using them.

Toll Station.—A telephone public pay station.

Toll System.—A system of charging for telephone service according to the number of calls sent, as distinguished from a yearly rental.

Tone.—A musical sound resulting from periodic vibrations, as opposed to *noise*.

Tongue of Relay.—In telegraphy, the lever upon which the armature of the relay electromagnet is mounted, and which carries the contact point.

Tooling.—Passing a hot tool over the surface of the rubber covering for a wire joint for the purpose of properly shaping it.

Toothed Core Armature.—A laminated armature built up of toothed core discs.

Toothed Core Discs.—Metal discs for building up laminated armature cores, having notches cut in the circumference, resulting in a succession of projecting teeth.

Top Hat Curve.—A curve of electromotive force or current which has nearly constant value, suggesting in shape a high hat.

Torch.—1. In construction, a flaring lamp producing a bright light which cannot easily be blown out; it usually consists of a large lamp burning naphtha or some other volatile hydrocarbon.

2. Any portable lamp with its burner on top of the container, which has a vertical flame, *not requiring a chimney to shield it.*
3. A blow pipe lamp burning gasoline, etc., employed by plumbers to heat wiped joints, or by painters to burn off old paint; also for blow pipe brazing, etc.

Toroid.—A surface generated by the revolution of a closed plane curve about an axis lying in its plane; also called *tore.*

Toroidal Coil.—A coil so wound as to form a toroid.

Toroidal Current Sheet.—An electric current conceived of as flowing in the form of a toroid.

Torpedo Cable.—A cable connected with a torpedo in order to explode it by electricity.

Torpedo, Electric.—A torpedo propelled, exploded, or in any way operated by electricity.

Torpedo Nets.—Heavy wire nets suspended about a war ship at anchor in order to protect it from torpedo attack.

Torque.—The value of a couple of forces tending to produce rotation; it is the product of one of the two forces by the perpendicular distance between the directions of the forces; the *moment of couple.*

Torque Efficiency.—The ratio of the actual torque of a motor to the torque which it would exert if free from frictional resistance.

Torricellian Vacuum.—The vacuum produced by filling with mercury a tube closed at one end, and immersing the open end in a vessel of mercury, so that the mercury in the tube descends until it is counterbalanced by the atmospheric pressure upon the mercury in the vessel. It is the space existing in the tube of a barometer above the surface of the mercury.

Torsiometer.—An instrument to measure the stress to which a bar is subject when in torsion, or under twisting strain.

Torsion.—1. In mechanics, that force with which a thread, wire, or rod of any material, returns, or tends to return, to a state of rest after being twisted.
2. The act of turning or twisting or the state of being twisted.

Torsional Strain.—The effects set up in a body by a torsional stress which tends to rupture it by *twisting* one fiber around another.

Torsional Strength.—Resistance to being twisted or wrenched off, in a direction about its axis; as, in case of shafting.

Torsional Vibration.—The vibration produced in a thread or filament by the application of a twisting force.

Torsion Balance.—An instrument for determining, by the torsion of a wire, the action of the forces of attraction and repulsion exhibited between two electrified spheres; *Coulomb's balance.*

Torsion Galvanometer.—A galvanometer in which the strength of an electric current is measured by the torsion produced upon the filament suspension of the needle.

Torsion Suspension.—A delicate method of suspending a needle for sensitive movements, as in a galvanometer, by a filament of silk or fiber of quartz; *fiber suspension.*

Total Contact.—A fault produced in a circuit by the accidental metallic contact of any part of it with a good conductor; *a full contact.*

Total Current Panel.—In a power station switchboard, a panel in which are the appliances for controlling the total current output of the station.

Total Disconnection.—A complete break in an electric circuit.

Total Earth.—In telegraphy, a fault in the line involving a complete grounding or connection with the earth; a *dead earth.*

Total Efficiency of Arc Lamp.—The ratio between the luminous energy radiated and the total energy transformed in the arc.

Total Heat.—In steam engineering, total heat is a term used in calculations: it represents all the heat, above 32° Fahr., in a pound of steam. It is the sum of the sensible heat units in the water, above 32° Fahr., and the latent heat of the steam.

Total Magnetic Induction.—The sum of the magnetic lines of force surrounding a

magnetized body and the lines passing through that body.

Total Pressure.—The pressure of steam above vacuum, also called *absolute pressure.*

Total Resistance.—A resistance equal to the sum of all the resistances existing in a circuit.

Tourmaline.—A mineral occurring in crystalline form, exhibiting pyro-electric properties in a high degree.

Tourniquet, Electric.—A light, delicately poised wheel with radiations terminating in points bent at right angles in the same direction; when connected with a source of electricity, it spins rapidly on account of the discharge of convection streams from the points resisting the surrounding air; *a reaction wheel.*

Tower, Electric.—1. A tower illuminated by electric lamps for an electrical display.
2. A tower for carrying a cluster of arc lamps, in the tower system of lighting.

Tower System of Electric Lighting.—A method of lighting a considerable area by a group of arc lamps carried on the summit of a tower instead of by independent lamps distributed over the territory.

Tower Wagon.—In an overhead trolley system, a repair wagon furnished with an elevated platform to give workmen ready access to the wires.

Towing, Electric.—The application of electricity to the towing of canal boats.

T. P. Switch.—Abbreviation for *triple pole switch.*

Track Bond, or Joint.—In an electric railway system, a method of joining the rails of the track in order to afford a continuous electric circuit. The ordinary fishplates are inadequate for the purpose, and *rail bonds* have to be employed to carry the current from one rail to the next. *Protected* bonds are placed between the channel plate and the rail, while those that are exposed by spanning the fishplate are known as *unprotected* bonds. They are of many varieties, consisting of copper plates, strips, or wires and sometimes of amalgam blocks.

Track Hanger.—A hanging support for an overhead railway, upon which a *traveling crane* or similar appliance may run. It is generally used in connection with a monorail on which run carrier trolleys, by means of which weights are transported from one department of a plant to another.

Track Instrument.—An electric contact device connected with a railway track, so that a train closes the circuit in passing, and gives a signal of its approach at the next station.

Track Switch.—A switch at a point in a railroad track where a branch enters the main line, by means of which a car may be led from one track to the other.

Traction, Electric.—The application of electricity to the propulsion of cars in street, and other railway systems.

Tractive Coefficient.—In electric traction, the ratio between the weight upon the driving wheels and the tractive effort.

Tractive Effort.—In electric traction, the pull transmitted by the gears from the armature shaft to the base of the car wheel. It is the torque in pounds developed at the rim of the wheels divided by total train weight in tons. It depends upon the rate of acceleration, grade, car friction, and air resistance.

Tractive Magnet.—An electromagnet designed to perform certain work by the movement of a plunger. The coil effects a pull upon the plunger which is drawn into the core chamber of the coil.

T Rail.—A form of rail employed in track work on railroads where street traffic does not have to be considered. It gets its name for the general resemblance of its cross section to an inverted letter T.

Trailer.—In electric traction, any car not furnished with motive power coupled to an electric car to be drawn after it.

Trailer Grapnel.—In submarine cable work, a second grapnel caused to trail behind the first in dragging for a cable.

Trailing Horns.—The projecting edges of the pole pieces of a dynamo which extend in a direction opposite to the rotation of the armature; the poles towards which the armature turns; *following horns.*

Train Describer.—An electrical device in a block system of railway signaling for the

purpose of indicating the position of an approaching train.

Train Wire.—A special telegraph wire reserved exclusively for the purpose of despatching trains in a block railway system.

Trajectory.—The curve described by the path of a projectile through the air.

Tram Car, Electric.—An electric street car.

Tram Rail.—A name given to a form of girder rail for street railway service because of a flat tram or tread which forms an extension of the head.

Tramway, Electric.—An electric street railway.

Transfer Bus Bar.—An auxiliary bus bar for transferring a feeder wire from one bus bar to another without shock.

Transfer of Heat.—In steam engineering, refers specially to the transmission of heat from a boiler furnace to the water within. Rapidity of circulation is necessary to prevent destructive overheating of the plates, which would soon happen if the heat transferred from the furnace were not carried away rapidly by the water. The coating of deposits of the feed water and sooty accumulations interfere with the transmission of heat. Thin plates conduct more rapidly than thick ones, and the rate of transmission area is more efficient than tube area, because of the greater concentration of heat there. The *rate of transmission* signifies the number of heat units transferred per hour, but the amount of heating surface will vary in different types of boilers.

Transfer Operator.—A telephone operator at the switchboard of a transfer system.

Transfer System.—A telephone system dispensing with the multiple switchboard, and depending for its operation at the exchanges upon the transfer of a connection from one part of a switchboard to another by means of trunk lines.

Transformation.—1. The changing of the value of electric current or pressure by means of the transformer.

2. The changing of electrical energy into mechanical energy, or into heat or light.

3. The changing of heat energy into mechanical energy.

Transformer.—An apparatus similar to the induction coil, for the purpose of transforming alternating currents, usually, of small quantity and high pressure into currents of large quantity and low pressure: it consists essentially, of two coils of insulated wire wound adjacently upon a soft iron core; the *primary* coil of high resistance consisting of many turns of fine wire is connected to the high potential circuit, and the *secondary* coil, consisting of fewer turns of coarse wire, furnishes the current at a reduced pressure; the *alternating current transformer*. This is a "step down" transformer; in a "step up" transformer the conditions are reversed, viz.: The primary winding being made up of a few turns of coarse wire and the secondary winding, of many turns of fine wire.

Transformer, Continuous Current.—A combination of dynamo and motor on the same shaft, one receiving current and the other delivering current, usually of different voltage, the motor being employed to drive the dynamo with a pressure either higher or lower than that received at the motor terminals. In one form two armatures are mounted on one shaft in a single field or in separate fields; one is a motor armature driven by the original current; the other generates new current. This is a "motor-dynamo," and it can transform continuous currents up or down. Another form of dynamotor is called the continuous alternating transformer. This is arranged so as to change a continuous into an alternating current or the reverse. A *dynamotor* or *rotary converter*.

Transformer Diagram.—A diagram giving a record of the working condition of a transformer.

Transformer Fuse.—A safety fuse included in the circuits of a transformer.

Transformer Guard.—A safety device for grounding the secondary circuit of a transformer, if, through a fault in the insulation, a contact is made between the primary and the secondary which would increase the potential in the secondary to a dangerous extent.

Transformer Lightning Arrester.—A lightning arrester included in a transformer circuit.

Transformer Operation.—If two separate coils of wire be wound on an iron bar, and a direct current be passed through one coil, no effect is produced in the other coil except at the moment of turning on the current, but if an alternating current be used instead, a current is at once produced and maintained in the second coil. By a very simple law the pressure or voltage of the two coils is approximately in proportion to the number of turns in each. Thus, if the primary coil be supplied with current of 1,000 volts, and the secondary coil has one-tenth as many turns, the pressure in the secondary will be approximately 100 volts. By the proper proportion of

the primary and secondary coils, the voltage may be raised to any pressure which can be safely transmitted.

Transformer Stampings.—Plates stamped from sheet steel and inserted in the completed coils of a transformer in the process of building up the laminated core.

Transformer Substation.—In an electric railway system extending over a considerable area, it is customary to distribute the power in the form of high tension alternating current, and transform it by means of step-down transformers and rotary converters to direct current for feeding the trolley wire. The apparatus for transforming is located in substations conveniently situated for meeting the demand for current at different sections of the line. Portable substations consisting of specially designed cars with complete substation equipment are frequently employed to provide for temporary excessive use of portions of the line, as at resorts or at the time of sporting events, etc.

Transforming.—The process of changing an electric current of small amount and high pressure to one of large amount and low pressure, or the reverse, by means of the transformer.

Transforming Down.—Transforming a current from a high to a low pressure through a *step down* transformer.

Transforming Up.—Transforming from a large current at low pressure to a small current at high pressure through a *step up* transformer.

Transient Currents.—Electric currents of brief duration.

Trans Illumination.—A means of diagnosis in electro-therapeutics, by throwing a powerful light through the parts of the body under examination.

Transit.—In engineering, the surveyors' transit is a portable instrument of the theodolite kind, designed for measuring both horizontal and vertical angles. It is provided with horizontal and vertical graduated circles, one or two levels, and a compass, and is mounted upon a tripod stand.

Transition Layer.—A layer separating the positive and negative values of electric or magnetic properties in a body.

Transition Resistance.—In electrolysis, a resistance offered to the electric current by the appearance of ions at the electrodes.

Translater, or Translator.—A name sometimes given to a telegraph repeater or relay.

Translator Keys.—In telegraphy, the signaling keys of a repeater or translator.

Translating Devices.—Devices of various kinds designed for utilizing the electric current as it passes into or through them: *electro-receptive devices.*

Translating Station.—In telegraphy, a station in which messages are repeated from one line to another.

Translucent.—The quality of a medium which has the power of transmitting light, without permitting clear vision through it, as distinguished from transparent.

Translucent Disc Photometer.—A photometer employing a screen of somewhat opaque paper made translucent, except a central spot (or as to a central spot alone) by being saturated with spermaceti, paraffin, or other suitable material; the screen is mounted upon a graduated scale, at one end of which the standard light is fixed, and at the other the light to be compared. By moving the screen along the scale until the spot becomes invisible, the relative illuminating powers of the two lights may be determined as the square of their distances from the screen; also called the *Bunsen,* or *grease spot photometer.*

Transmission.—To send through, or across, transfer. Up to a certain limited distance, the useful effect of the energy created at a certain point, can be best and most economically transferred by *belting* of various materials, *pulleys* and *shafting.* For greater distances there are four principal methods in use for the transmission of power: (a) electricity, (b) water (hydraulic power), (c) air (pneumatic power), (d) wire rope.

Transmission Circuit.—The circuit of conducting wires employed to convey electric power developed at one station to the point at which a motor is to be driven or other work done, at a distant station.

Transmission Dynamometer.—A dynamometer which is employed to measure power in the process of transmission from its source to the point where it is to be utilized.

Transmission, Electric.—The conveying of electric power from a generating station, by means of transmission circuits, to distant stations where the power is consumed.

Transmission Insulator.—A high potential insulator for use in transmission circuits.

Transmission of Power.—The conveyance or transmission of energy from one point to another, more especially from a convenient central source of power to the point where it is desired to be applied. For short distances, shafting, belts, pulleys, ropes, etc., are employed; medium distances may be covered by wire rope transmission; longer distances may need hydraulic power, compressed air, or electricity. Each type of transmission has its advantages for certain circumstances.

Transmitter.—1. In telephony, the device into which the speaking is done so that undulatory currents are set up in the line by means of which the sounds of the voice are transmitted. The modern transmitter is of the granular carbon type. It contains two flat carbon electrodes, one mounted on a vibrating diaphragm and the other stationary. Between them is introduced a mass of granular carbon. The vibration of the diagram caused by the voice transmits variations in pressure through the electrodes and carbon grains and thus varies the resistance of the circuit.

2. In telegraphy, the key used for sending signals over the line. It consists of a pivoted lever with a finger piece. When depressed it closes the circuit through the line, and when released it rises and opens the circuit, transmitting dot and dash signals according to the Morse code.

3. In wireless telegraphy, a sending key which controls the duration of the sparks at the spark gap thereby sending out the waves in groups corresponding to the dots and dashes of the Morse code.

Transmitted Power.—Power that is conveyed from a generating point to a distant place where it is utilized.

Transmitting Station.—In telegraphy, the point from which a message is sent.

Transposing.—A method of inter-crossing telephone wires in pole lines so as to avoid electrostatic induction between circuits.

Transposition.—In pole line construction, an arrangement of telephone wires, consisting of intercrossing the different wires at definite intervals, for the purpose of eliminating electrostatic induction between circuits.

Transposition Insulator.—A double grooved insulator employed in the transposition of telephone lines in an overhead circuit.

Transposition Wires.—Bridle wires sometimes employed in making transpositions, for bridging across from one wire to another at the transposition pole.

Transverse.—Crosswise or in the direction at right angles to the length of anything; lying or being across anything; the opposite of longitudinal.

Transverse Vibration.—A vibration having a direction at right angles to the length of a vibrating body, as a string or rod.

Traveling Arc.—An unsteady arc sometimes occurring between the carbons of an arc lamp employing certain types of rods, in which the arc seems to wander about the ends of the carbons, producing a varying light.

Traveling Crane.—A crab or winch mounted on a girder which spans a workshop, or the like. The crab can move sidewise upon the traveler, while the latter runs on rails up and down the building. In some instances, the traveling crane carries its own boiler and steam cylinders, in others, the three movements are taken care of by separate electric motors. Other plans are a drive by endless cotton or hemp ropes, from the shop shafting, or through a lay shaft and worm gearing, like the traverse shaft on a lathe.

Traveling Dynamo.—A dynamo resting upon a movable base.

Traversing Motor.—An electric motor for traveling back and forth over a short distance.

Tread of Car Wheel.—The outer rim of the car wheel apart from the flange.

Treated Coked Filament.—A coked filament for an incandescent lamp further treated by the flashing process to prevent occlusion of gases.

Tree Insulator.—A form of insulator by means of which an overhead wire may be supported by a tree without suffering any strain from the swaying or other motion the tree may make.

Tree System of Parallel Distribution.—A system of incandescent lamp distribution in which the mains and branches are so related, as to resemble the arrangement of the stem and branches of a tree, diminishing in size towards the extremities of the circuit.

Tree Wire.—A specially insulated wire designed to resist injury from chafing against trees.

Trega.—A prefix to a unit of measurement to denote one trillion times that unit.

Tregadyne.—A unit of force equal to a *trillion dynes.*

Tregerg.—A unit of work equal to a trillion ergs, or nearly *thirty three foot tons.*

Tregohm.—A unit of electrical resistance equal to a trillion ohms.

Trembler.—A vibratory device used in connection with the jump spark method of electric ignition for gasoline engines; a vibrating blade or spring having a weight attached to the end and actuated by the weight dropping into a recess in the rotor. This causes the blade to "tremble" and make a number of contacts which connects and interrupts the primary circuit, so that the coil produces a series of sparks between the points, rather than a single flash at the time of ignition; also called a *mechanical vibrator.*

Trembling Bell.—An automatic electric vibrating bell with a self-acting contact breaker; a *vibrating bell.*

Trestle.—A movable frame or support for anything; as, scaffolding, consisting of three or four legs secured to a top piece, and forming a sort of stool or horse, used by carpenters, masons, and other workmen; also, a kind of frame work of strong posts or piles, and crossbeams.

Trevelyan Experiment.—An experiment exhibiting the thermal properties of metals, in which a piece of brass, called a rocker, is heated to about 200° C., and caused to rest on projecting edges in its surface upon a cylinder of lead, the rocker then begins to oscillate to and fro upon its edges, giving forth a definite musical note.

Triangle of Forces.—In physics, the triangular figure which graphically represents the magnitude and direction of *three forces in equilibrium* which are lying in one plane.

Tricon.—A unit of length equal to *one-trillionth of a meter.*

Tricro.—A prefix to a unit of measurement to denote one trillionth part of that unit.

Tricro-ampere.—A unit of current equal to one trillionth part of an ampere.

Tricro-farad.—A unit of electric capacity equal to one trillionth of a farad.

Tricrohm.—A unit of resistance equal to one trillionth of an ohm.

Trifilar Suspension.—A suspension, as of a needle, by three equally long threads for measuring forces of rotation.

Trigonometrical Functions.—Certain functions of angles, such as the *sine, tangent* and *secant,* employed in trigonometry in investigating the relations between the sides and angles of geometric figures.

Trigonometry.—That branch of geometry which treats of the relations of lines and angles by algebraic methods.

Trimmer.—A workman employed to renew the carbons in arc lamps.

Trimming.—1. Stripping the insulation from a conductor and cleaning the surface of the wire at a point where a wire junction is to be made.
2. Renewing the carbons of an arc lamp.

Trimming Brushes.—At certain intervals, according to the care taken to reduce sparking, and the length of time the machine runs, the brushes will fray out or wear unevenly, and will therefore need trimming. They should then be removed from the brush holders, and their contact ends or faces examined. If not truly square, they should be filed or clipped with a pair of shears, the course of treatment differing with the type of brush.

If metal strip brushes, the feathered-out ends should be clipped square with a pair of shears, the ends thoroughly cleaned from any dirt or carbonized oil, and replaced in their holders. Gauze and wire brushes require a little more attention. When their position on the commutator has been well adjusted and looked after, so that little or no sparking has taken place, it will generally be found only necessary to wipe them clean, and clip off the fringed edges and corners with the shears, or a pair of strong scissors. If, however, the machine has been sparking, the faces will be worn or burnt away, and probably fused. If such is the case, they will need to be put in the filing clamp, and filed up square and true, as directed above.

If the contact faces of the brushes are very dirty and covered with a coating of carbonized oil, etc., it will be necessary to clean them with benzoline or soda solution before replacing.

Triode Working.—In synchronous multiplex telegraphy, the simultaneous transmission of three messages over the same wire.

Trip Gear.—The arrangement of levers, latches, etc., by means of which the admis-

sion valves of Corliss steam engines are released from the valve gear, so as to effect a sudden cut off by the aid of springs, steam, air pistons, etc. The position at which the valves are *tripped* is determined by the governor, according to the load.

Triphase.—In alternating current work, a term sometimes used for *three-phase.* The armature of a triphase alternator is wound with three sets of independent circuits in which the pressure waves follow one another with a phase difference of 120°.

Triphaser.—A three-phase alternator. An a. c. generator having its armature wound with three independent circuits, generating electromotive forces that are 120° apart, a *three-phaser.*

Triple.—Consisting of *three things* united or of three parts; threefold; multiplied by three.

Triple Carbon Arc Lamp.—A variety of arc lamp employing three carbons instead of two.

Triple Connector.—A connecting sleeve, binding post, or similar device for joining the ends of three wires.

Triple Expansion.—A steam engine in which the expansion of the steam is effected in *three stages* by successive cylinders, known as the high pressure, intermediate, and low pressure. The cranks are usually at equal angles of 120°; thus a very uniform turning effort is obtained, and the temperature and pressure range of each cylinder is not very large; these factors, together with the high rate of expansion, make a very economical engine.

Triple Petticoat Insulator.—A line wire glass insulator having three deep flanges or petticoats around the base.

Triple Pole Single Throw Switch.—A switch which opens or closes three circuits by a single throw.

Triple-pole Switch.—A switch which is provided with three contacts by which it may open and close three electric circuits: a *three-point* switch.

Triplex Telephony.—A system of telephony in which three messages may be transmitted simultaneously over the same wire in one direction.

Tripod Roof Support.—In overhead line construction, a tripod for supporting wires running over a roof.

Tripping Coil.—A coil in a circuit breaker which trips or unlocks the spring which controls the contacts, and opens the circuit when the current reaches a definite value.

Trivalent.—Having the valency, or combining power, of three units; as, a trivalent or triad atom.

Trolley.—A grooved brass wheel carried at the upper end of a trolley pole and pressed upwards against the under side of the trolley wire, by which the current is collected and conveyed to the controlling switch of an electric car.

Trolley Base.—A base resting upon the roof of a trolley car, upon which the trolley pole is mounted in a pivoted frame, provided with springs to press the wheel against the trolley wire.

Trolley Base Frame.—The pivoted frame by means of which a trolley pole is mounted upon its base.

Trolley Bus Bar.—In a railway power house, the bus bar leading to the trolley line.

Trolley Car.—An electric railroad car in which the current for the motors is taken from an overhead wire by means of a trolley with grooved wheels, which is held up against the wire by a flexible pole. The wires from the contact wheels pass down the pole to the car controller and thence to the motor, the return circuit usually being through the rails.

Trolley Car Controller.—The switch by means of which the motorman of a trolley car governs its movements: it consists usually of a vertical cylinder containing contact points pressing against flat springs, and is operated by turning a handle at the top.

Trolley Contact.—The running contact obtained by a trolley wheel against the trolley wire.

Trolley Cord.—A cord attached to the upper part of a trolley pole, and hanging within easy reach of the rear platform of a trolley car, for the purpose of reversing the

trolley, or for restoring it to the line when accidentally displaced.

Trolley Crossing.—1. An insulated device suspended at the intersection of trolley wires, which permits the trolley on one line to pass another line without electrical contact.

2. An uninsulated guiding plate used at crossings, at which the angle is less than 75°, and protected by section insulators on either side of it.

Trolley Cross-over.—A device employed at the intersection of two trolley lines to carry the trolley wires past each other. They are made in varying angles to suit conditions, and are sometimes provided with wood insulation for use where the two lines belong to different systems. It is also known as a *crossing-ear* or *crossing.*

Trolley Ear.—A piece of metal, grooved to fit the trolley wire, for the purpose of attaching the wire to the insulator which supports it; a *suspension ear.*

Trolley Fork.—The forked head of a trolley pole carrying a harp for the spindle of the trolley wheel.

Trolley Frog.—A device situated at a point where trolley lines branch from each other, so that the trolley wheels may be guided to the proper line; right hand, left hand and symmetrical frogs are designed to meet all requirements.

Trolley Hanger.—The trolley ear and insulator constituting the supporting device of a trolley wire.

Trolley Harp.—A forked device fitted to the head of a trolley pole for carrying the spindle of the trolley wheel.

Trolley Ice Clearer.—A trolley wheel having its groove provided with projections for clearing a trolley wire of ice. *A sleet wheel.*

Trolley Mast —In an overhead system of electric traction, the pole by means of which the trolley wheel is kept in contact with the wire. It is a rod of hard drawn steel 12 to 15 feet in length, and from 1½ inch to 1 inch in diameter, slightly tapering. A *harp* is riveted to the top of the pole, and within this the trolley wheel rotates.

Trolley Pole.—A pole of metal or wood, usually about 12 feet in length, mounted on a suitable base upon the roof of a trolley car, for holding the trolley wheel against the wire and conveying the current to the motor.

Trolley Pull-off.—A hanger for suspending and holding in place a trolley wire in rounding a curve. It is a device for clamping a wire, and by means of one or two lugs fixing it by a span wire to a supporting pole.

Trolley Section.—A length of trolley wire with one or more feeders, forming a section of the line, and insulated from adjoining sections by section insulators, so that in case of accident at any point on the line, only the section affected need suspend operation.

Trolley Section Insulator.—A device placed in an overhead trolley wire at a point where two divisions of the line join that are fed by separate feeders from the power house. The sections of the wire are attached to two castings which are separated by hard wood insulating material, permitting the trolley wheel to run smoothly across.

Trolley Splice.—A method of uniting the ends of two trolley wires by means of a conducting sleeve over the junction point.

Trolley Stand.—The spring base pivoted to the top of a trolley car to which the trolley pole is clamped; the *trolley base.*

Trolley Strain Insulator.—An insulator designed to withstand strong tension inserted in a trolley strain wire.

Trolley Strain Wires.—Wires employed in connection with strain insulators to hold the trolley wire at the proper tension, especially at curves in the line.

Trolley Traction.—The use of the trolley principle in the electric propulsion of railways.

Trolley Truck.—The truck on which the body of a trolley car rests, and which carries the motor.

Trolley Wheel.—In an electric street railway system with an overhead line, the rotary device by means of which contact is made with the trolley line and current derived for the motors. It is a brass grooved wheel from four to eight inches in

diameter, which turns on an axle carried in a *harp* riveted to the upper end of the trolley pole.

Trolley Wire.—The bare copper conductor forming the overhead circuit for conveying the electric current from the generating stations to the motors of cars through the trolley.

Truck.—The group of wheels and supporting framework containing the brakes, motors and driving gear of an electric railway car. There are two chief types of trucks: (*a*) the *single truck* having four wheels with a single motor on each axle, one only being used to support the car body; and (*b*) the *double truck*, each with four wheels of the same size, carrying a motor on each axle, two trucks being used per car. The *maximum traction* truck has two large and two small wheels, so arranged that the weight will largely rest on the large wheels which are driven by the motor.

True Contact Force.—A kind of electromotive force which is supposed to exist at the junction of two dissimilar metals upon the passage of an electric current, as exhibited in the Peltier effect.

True Galvanometer Constant.—The strength of the electromagnetic field at the middle point of a galvanometer coil when a unit current passes.

True Ohm.—The true value of the ohm as expressed in the *international ohm*, as distinguished from the legal or British Association ohm.

True Resistance.—The ohmic resistance in an electric circuit, as distinguished from the counter electromotive force, or *spurious* resistance in the circuit.

Trumpet, Electric.—An electric buzzer reinforced by a megaphone tube, or trumpet.

Trunk Call.—A telephone call coming over a trunk line.

Trunk Connection.—A telephone connection obtained by means of a trunk line.

Trunking.—Telephone traffic over trunk lines.

Trunking Out Telephone Switchboard.—A switchboard designed for use with trunk lines in long distance transmission.

Trunking Switchboard.—One of the switchboards employed in a telephone exchange, based upon the transfer system in which connections are made by means of trunk lines.

Trunk Lines.—1. In a telephone system, the main lines between stations at distant points for the transmission of long distance messages.

2. The lines connecting telephone exchanges, as distinguished from the subscribers' lines.

3. In the transfer system, the lines connecting the *a* and *b* switchboards of the exchange.

Trunk Line Working.—Telephone transmission over trunk lines, as distinguished from that over subscribers' lines.

Trunk Operator.—A telephone operator employed at the switchboard of a trunk line.

Trunk Switchboard.—In a telephone exchange, the switchboard controlling the trunk lines.

Trunk Wire.—In an electric car wiring system, the wire which carries the total motor current of the car. It runs from the trolley wheel, third rail shoe or slot plow, according to the system employed, to the point of application to the motor circuit.

Trunk Working.—In telephony, when it becomes necessary to employ more than one central office to make connection between subscribers, so-called *trunk lines* or *trunks* are provided between the stations. These lines are intended to establish communication in one direction only, each station being supplied with a number of outgoing and incoming trunks.

Trunnion Screws.—A pair of screws projecting so as to form a support about which a movable device may swing.

Trussed Pole.—A telegraph pole stiffened against special strain by means of an iron truss, when circumstances do not permit the use of proper stays.

Truth.—A shop term to denote the accuracy of work. The getting of a straight edge or grindstone or square into correct outline is termed *truing up*. A shaft or

spindle is true when it is straight or in line, and of constant or correct diameter. A piece of stuff is true when of equal thickness, or when not winding; a cylindrical piece of work is true when it fits to gauge or calipers. Tools used for measurement are employed to check the *truth* of work.

T Shaped Spark.—A spark having three branches sometimes seen in the discharge of a condenser through an induction coil.

Tube of Force.—A tubular surface bounded by lines of force.

Tube of Magnetic Force.—A system of lines of magnetic force drawn through every point of a closed curve, forming a tubular surface.

Tube of Magnetic Induction.—A tubular surface having its sides formed of lines of magnetic induction.

Tube Surface.—In steam engineering, the total area of the exterior surface of the tubes in a surface condenser. The extent of this area is variable in different engines, being dependent on the efficiency of the cold water circulation, but it may be taken for marine engines at from 1.5 to 3 square feet per I. H. P. for terminal pressures ranging from 6 to 30 lbs. absolute.

Tubular Braid.—An insulating braid woven in tubular form for covering a wire joint.

Tubular Conductors.—Electric conductors in the form of hollow tubes.

Tubular Core.—An iron core for an electromagnet in the form of a hollow tube, sometimes employed instead of a solid core.

Tubular Current.—An electric current considered as flowing only upon the surface of a conducting wire.

Tubular Drop.—A tubular form of telephone clearing out drop designed to overcome mutual induction with other drops in the switchboards.

Tubular Electromagnet or Magnet.—A type of electromagnet designed to offer powerful attraction through a short distance; it consists of a short cylindrical electromagnet with an outer tube united to the iron core at the bottom; an *iron clad electromagnet.*

Tubular Pole.—A hollow steel pole usually of telescopic form, provided with one or two bracket arms for carrying the trolley wire in street railway systems.

Tumbling Box.—A revolving box into which articles to be electroplated are caused to rub against one another for a preparatory polishing.

Tuner.—A term sometimes applied to a *synchronizer* or *phase indicator,* a device for indicating the synchronous relation between two alternators which are to be connected in parallel. The simplest arrangement consists of one or more incandescent lamps in series which show light or dark simultaneously at synchronism. For large alternators other devices are necessary. One type indicates by a pointer upon a dial whether the incoming machine is running too fast, too slow, or in exact step.

Tungsten.—A somewhat rare metal used as the filament in the tungsten incandescent lamp. It is steel gray in color, very heavy (specific gravity 19.129), and hard enough to scratch glass. It passes directly into vapor at a very high temperature without entering the liquid state, and has a lower specific resistance than carbon.

Tungsten Filament.—The metal tungsten being too brittle to be drawn into wire, fine particles of the metal are made into a paste with binding material and squirted through a die. After drying, the particles are welded into a continuous wire.

Tungsten Lamp.—A type of metallic filament incandescent lamp employing a filament composed of the metal tungsten. The tungsten is mixed in a finely divided state with a solution containing a binding material, and then squirted into filaments. Tungsten lamps work on either direct or alternating current circuits, and are not affected by changes in voltage. The light given is white and brilliant, and their economy is high with remarkably long life, though the filaments are brittle and liable to break from any vibration.

Tungsten Steel.—A satisfactory steel alloy for permanent magnets. It contains 3.444 per cent tungsten.

Tungstometer.—A device for showing the comparative wattage consumption of the tungsten and ordinary filament lamps. It consists of three elements: (a) a measuring system; (b) a connection system consisting of an insulated tube on the upper end of which is a swivel type Edison screw plug,

and on the lower end an Edison lamp socket; (c) a special computing scale located just below the meter.

Tuning.—In wireless telegraphy, the adjusting of the receiving apparatus of one station to the sending apparatus of another, so that the detector at the receiving station shall respond only to the waves sent from that particular transmitter, without interference of waves of other frequencies; *syntony*.

Tuning Fork Dynamo.—A form of dynamo in which the armature, instead of rotating, performs oscillatory movements in the electromagnetic field; an *oscillatory dynamo* or *generator*.

Tuning of Electric Circuit.—Bringing an alternating current circuit into a harmony of relation with another with respect to capacity, inductance, resistance and frequency.

Tunnel Armature.—A form of dynamo armature in which the windings are sunk below the surface in tunnel-like grooves.

Turbine.—A machine in which a rotary motion is obtained by transference of the momentum of a fluid; broadly speaking, the fluid is guided by fixed blades, attached with a casing, and impinging on other blades mounted on a drum or shaft, causing the latter to revolve.

Turbine Pump.—A multiple centrifugal pump, with several impellers in series, suitable for pumping against high heads. More generally known as *series* or *multistage centrifugal pump*.

Turbo-generator.—A dynamo or alternator driven by a steam turbine and coupled directly with it, usually mounted upon the same base plate; a *turbo-generator set*.

Turnbuckle.—A device consisting of a metal sleeve or loop with a screw thread at one end and a swivel at the other, or a screw thread at both ends, for tightening up stay rods, and similar purposes.

Turnbuckle Insulator.—A form of insulator employed in a trolley line on span or pull off wires, for the purpose of adjusting or tightening up the wires.

Turn Down Incandescent Lamp.—A lamp provided with a high resistance unit arranged in its socket so that the quantity of light can be changed at will by inserting more or less of the resistance.

Turning Moment.—The *torque*, the moment of a couple which acts upon a body so as to produce rotation. In the case of the armature of an electric motor the torque is measured in the number of pounds pull at a radius of one inch or of one foot. It may also be measured in dyne centimeters and gram centimeters.

Turn Out.—In a single track trolley line, a loop or side track to enable cars to pass in opposite directions.

Turpentine.—A name given both to the crude thickly flowing liquid obtained from certain coniferous trees, and to the product of distillation from crude turpentine, more properly called *oil of turpentine*. The oil of turpentine is a mixture of various terpenes varying in nature according to the tree from which the crude turpentine was derived. Its chief use is in thinning oil varnishes.

Turret Turning Motor.—An electric motor by means of which a revolving turret on a battleship is operated.

Turtle Back Electrotype.—An electrotype with a slightly convex surface for use in a cylindrical printing press; a rotary electrotype.

Twigs.—A name sometimes given to the extreme sub-branches in a tree system of distribution to incandescent lamps.

Twin Cable.—A cable composed of a number of conductors twisted in pairs.

Twin Conductor.—A cable containing two insulated conductors running parallel.

Twin Wire.—A conducting wire made up of two separately insulated wires.

Twisted Cable.—A bunched cable in which the conductors are first twisted in pairs, then two pairs are twisted together, a second set of two pairs are then twisted with the first, and so on, for the purpose of eliminating inductive disturbances.

Twisted Strip Voltmeter.—A voltmeter employing a twisted platinum-silver strip which tends to twist or untwist under

changes of temperature produced by the flow of the electric current.

Twisted Wires.—In overhead telephone line construction, wires transposed, or caused to recross each other at stated intervals, for the purpose of preventing inductive disturbances.

Twisting Strain.—In mechanics, a torsional or winding strain; a strain which will wrench or twist out of shape.

Twist System.—A system of running cable wires in pairs, twisted together for the purpose of overcoming the inductive effect between them.

Two Circuit Armature Winding.—A method of winding the armature so that the current is divided between two paths only, whether in single pole or multi-polar dynamos.

Two Circuit Dynamo.—A dynamo whose armature has a two circuit, or two path winding.

Two Circuit Multiple Winding.—An armature winding in which each of the independent sets of coils divides the current into two paths.

Two Coil Armature Winding.—In an alternator, two coils in the armature winding supplied for each field magnet pole.

Two Cycle.—A type of internal combustion engine in which the four operations of charging, compression, explosion and expulsion are carried out during two strokes of the one piston. The piston usually serves as exhaust valve; the exploded charge escaping through ports in the cylinder wall, which are uncovered by the piston as it nears the extremity of its outward or power stroke. The incoming charge is either admitted by a separate valve or pump, or else passes into the cylinder by ports opposite the exhaust port, the charge being deflected to the end of the cylinder by a ridge upon the piston, and *scavenging out* the products of combustion as it comes in. Compression ensues upon the closing of inlet and exhaust ports by the piston.

Two Part Commutator.—A commutator composed of two metallic segments for use with a single coil armature winding and a bipolar field.

Two Phase Alternating Currents.—Two alternating currents of the same frequency, but having a difference in phase of a quarter of a period; a *diphase* or *quarter phase alternating current.*

If two identical simple alternators have their armature shafts coupled in such a manner, that when a given armature coil on one is directly under a field pole, the corresponding coil on the other is midway between two poles of its field, the two currents generated will differ in phase by a half alternation, and will be two-phased currents; similarly, three-phased currents could be generated by coupling the armatures of three simple alternators so that the corresponding coils on each are equally "staggered" with respect to each other.

Two-phase and three-phase currents differ in this respect; the two-phase system requires four wires to connect the generators with the motors, and their action is that of two distinct and separate circuits through which are passing simple alternating currents of electricity which act upon the revolving part of the motor like the two cranks on a cross connected engine at right angles to each other, or one 90 degrees in advance of the other.

Two Phase Alternator.—A dynamo producing two alternating currents having a difference in phase of a quarter period; a *diphaser, a two phaser.*

Two Phase Armature.—The armature of a two phase alternator so wound as to produce two phase currents.

Two Phase Armature Winding.—An armature winding for producing two phase currents; it consists in adding to the winding of a single phase alternator a second set of armature coils with the active portion exactly midway between those of the first set.

Two Phase Circuit.—A circuit composed of three or four conductors for conveying two phase currents.

Two Phase Currents.—Currents in which the terminal voltages on the two circuits differ in phase by ninety degrees.

Two Phase Electromotive Forces.—Electromotive forces in a two phase alternating current.

Two Phase Field.—An electromagnetic field created by two phase currents.

Two Phase Motor.—An induction motor which, instead of having a single field winding, is furnished with two distinct windings, each supplied with a single phase alternating current of the same frequency but differing in phase one quarter of a period; a *diphase motor.*

Two Phaser.—A two phase alternator. An a. c. dynamo having two distinct wind-

ings upon its armature each with its own pair of collector rings, and so wound that the electromotive force generated in one winding shall be in quadrature with the electromotive force of the other; that is the two E. M. F's shall be 90° apart.

Two Phase System.—A system of electrical distribution operated with two alternating currents differing in phase by a quarter of a period, transmitted through circuits consisting either of four independent wires, or of three wires, one of which is common to the two currents.

Two Phase Three Phase Transformer.—A transformer designed to convert two phase into three phase currents; a *diphase triphase transformer.*

Two Phase Transformer.—A transformer in a two phase system.

Two Point Switch.—A switch provided with two contacts; a *two way switch.*

Two Pole Dynamo.—A dynamo having two field magnet poles.

Two Way Door Trigger.—A catch which acts so as to ring an electric alarm on the closing as well as the opening of a door.

Two Way Splice Box.—In underground cable construction, a splice box furnished with two channels or ducts for a straight line.

Two Way Switch.—A switch provided with two contacts so that connection may be made with two separate circuits; a two point switch.

Two Way Trolley Frog.—A frog suspended in a trolley line for properly guiding the trolley wheel at a point where the road forks into two.

Two Wire Mains.—The mains employed in a two wire system of electrical distribution.

Two Wire Moulding.—A moulding having two channels or grooves for accommodating a pair of wires.

Two Wire System.—A system of electrical distribution employed in incandescent lighting in which only two mains are required, as distinguished from the *three wire* system in which a third or balance wire is introduced.

Tying In.—Fastening an overhead line wire to the insulators by means of tie wires.

Tyndall, John.—Born 1820, died 1893; an English physicist, distinguished for his researches in electricity and magnetism, as well as in other departments of physics.

Type Printing Telegraph.—A telegraph system in which messages as received are printed in the ordinary letters of the alphabet upon a strip of paper. It depends for its operation on uniform simultaneous rotations of a cylinder or wheel at the sending station, and a type wheel at the receiving station. The *stock ticker* is a familiar example of a printing telegraph.

Typewriter, Electric.—An adaptation of electricity to the operation of the typewriter, in which the keys cause the closing of electric circuits which produce electromagnetic action of the type levers.

U.—Abbreviation for *unit.*

Udometer.—An instrument to determine the quantity of rainfall. A *rain gauge.* An *ombrometer* or *pluviometer.*

Ultimate Capacity of Switchboard.—The maximum number of subscribers' lines that a telephone switchboard is capable of accommodating.

Ultimate Set.—In materials, the difference between the length of a specimen plate or bar before testing, and at the moment of fracture; and given in percentage of the length. This amount, in conjunction with the reduction of area, is a measure of the ductility of the plate or bar, since it is measured after fracture, by laying the broken ends together. It is also termed the *set after fracture.*

Ultra-incandescent Lamp.—A variety of incandescent lamp in which the filament is treated with a radio-active substance in order to enhance the brilliancy of the light.

Ultra-ultra-violet Rays.—Light rays at the extreme limit of the ultra-violet rays.

Ultra-violet Rays.—Rays of light existing beyond the violet light of the visible spectrum, having a more rapid rate of vibration than 800 billion vibrations per second.

Umbrella Type Alternator.—An alternator in which the rotating part is suspended from a vertical shaft by a six-armed spider.

Unbalanced Load.—A load that is borne in unequal proportions by the different dynamos in the generating system.

Unbalanced Polyphase System.—A polyphase system of electrical distribution in which current and phase are unsystematically distributed through its branches.

Unbuilding.—The spontaneous loss of electromotive force in a self-exciting dynamo; the reverse of *building up.*

Undamped Oscillations.—Electric oscillations produced in a circuit by an alternating current of very high frequency that continues uninterruptedly. It may be represented by a regularly repeated curve.

Undemagnetizable.—Incapable of being deprived of magnetism.

Under-contact Third Rail.—A method of mounting the conducting rail in the third rail system of electric traction, in which the rail is supported at intervals by iron brackets which hold suspended insulation blocks by a special clamp, so that the under surface of the rail is presented to make contact with the upper surface of the shoe. Between the supports, the upper side of the rail is guarded by a wooden sheathing. The advantages of this method are, (*a*) less danger from the live rail, (*b*) less strain on the insulators, (*c*) protection from the weather, and (*d*) that it is self-cleaning.

Underframe.—A term sometimes applied to a trolley car truck.

Underground Cable.—An electric cable run through a suitable conduit beneath the surface of the ground.

Underground Cable Supports.—Hooks for supporting underground cables in passing around the sides of manholes.

Underground Cable Terminal.—A box provided with terminals for the wires in an underground cable at a point where the cable leaves the ground.

Underground Conductor.—An insulated electrical conductor run underground, as distinguished from an overhead or aerial conductor.

Underground Electric Conduit.—A passageway for underground cables and conductors, built up of single or multiple-duct sections of vitrified clay, cement, or iron laid in concrete, forming a continuous system of protective tubing from manhole to manhole.

Underground Electric Tube.—An underground conduit consisting of a

wrought iron pipe laid directly in the earth: after the conductors are introduced the tube is filled with an insulating compound forming a "solid" conduit.

Underground Railway.—One wholly or in large part beneath the street surface of a city.

Underground Telephone Cable.—A telephone cable laid underground instead of being carried overhead on poles.

Underground Telegraph.—A telegraph system employing underground wires instead of a pole line.

Underground Trolley System.—A trolley system in which the trolley wire is run in an underground slotted conduit midway between the rails of the track; the connection with the motor being effected by means of a shoe introduced through the slot; the *conduit* trolley system.

Underground Tube.—A system of underground line construction for electric distribution, in which conductors are run through iron pipes filled with an insulating compound and buried in the ground. A tube usually contains three copper rod conductors wound with a serving of hemp to further insulate them. The conductors are not removable, as the insulating compound solidifies after being run into the tube. Tubes are made in 20 ft. lengths, joined by coupling boxes with removable covers.

Underload Circuit Breaker.—A switch employed especially in charging storage batteries, for opening the circuit if the current becomes too feeble. If the charging current weakens too far, the battery will commence to discharge and tend to drive the charging dynamo as a motor. One type, used with motor starting boxes, has a switch arm held in place by an electromagnet against the pull of a spring. When the current weakens, the spring pulls away the arm and opens the circuit.

Under Running of Cable.—A method of examining a cable laid across a river bottom, in which the cable is passed over a sheave in a boat from bow to stern, as the boat moves along the line of the cable.

Under Running of Incandescent Lamps.—Applying a voltage below the normal to an incandescent lamp circuit, thereby reducing the efficiency, but prolonging the life of the lamps.

Under Running Sheave.—A sheave over which a sub-aqueous cable is passed in the operation of under-running a cable in examining for faults.

Under Running Trolley.—A method of contact employed in the ordinary street railway systems, in which the trolley wheel runs along the under side of the trolley wire.

Undertaker.—A term sometimes applied to a person who furnishes electrical energy for lighting or other purposes.

Undertype Dynamo.—A form of simple two pole field magnet machine in which the armature is placed below the yoke, the field magnets being inverted, instead of standing upright. The advantage of this arrangement is that the moving parts are brought low down, lessening the vibration.

Undertype Field Magnet.—A field magnet employed in an under-type or inverted dynamo in which the armature is placed below the field magnet coils and yoke.

Underwriters' Pump.—A fire pump, of a pattern approved by Insurance Underwriters or by the Insurance Corporation's Surveyor, such as is fitted in large buildings in connection with the fire fighting apparatus, to maintain the water supply for hose, hydrants, sprinkler tanks, etc.

Underwriters' Rules.—The *National Electrical Code;* a set of rules and requirements drawn up by the National Board of Fire Underwriters for the installation of electric wiring and apparatus. Copies of these rules may be had free of cost from The National Board of Fire Underwriters, New York or Chicago, or from any local inspection bureau. All interior wiring must be done in accordance with this code in order that buildings may be insured.

Undulation.—A wave motion, as of an alternating or undulatory electric current.

Undulatory Current.—An electric current uniform in direction, but varying in strength according to the law governing the velocity of air particles in a sound wave.

Undulatory Discharge.—An *oscillatory* discharge, a series of rapid alternations of charges which are set up when the plates of a charged condenser are joined by a conductor, the plates of the condenser being positively and negatively charged in turn. A high frequency alternating cur-

rent flows in the conductor, but it soon dies away as the energy of the condenser passes into heat.

Undulatory Winding.—A method of armature winding, usually known as *wave winding.* Each step of this winding is progressive, and two successive winding elements have the appearance of two successive waves. Wave winding has only a single *pitch*, and all steps are made equal in order to render the winding symmetrical.

Unevenly Distributed Winding.—An armature winding running in grooves which are arranged unevenly upon the surface of the armature.

Unflashed Filament.—An incandescent lamp filament composed of cellulose which has been reduced to carbon under high temperature, and is ready for the final process of "flashing," in which the filament is heated electrically while surrounded by dense hydrocarbon vapor.

Uni-coil Armature Winding.—A method of winding the armature of an alternator, in which a single coil or slot is provided on the armature for each field-magnet pole.

Uni-directed Current.—The alternating current generated in the armature of a dynamo must be commuted or rectified in order to draw a direct current from the machine. This is effected by the *commutator* which causes the current to flow continuously in one direction, and the *brushes* which lead this unidirected current into the external circuit.

Uni-directional Current.—An electric current of uniform direction; a *direct current.*

Uni-directional Discharge.—An electric discharge having uniform direction throughout its range.

Uni-directional Electromotive Forces.—Electromotive forces having a common direction.

Uni-directional Leak.—A leak occurring in an electric circuit in a constant direction.

Unifilar Suspension.—A suspension, as of a needle, by a single thread for measuring forces of rotation.

Uniform Density of Field.—A field of force containing a uniform number of lines of force throughout its area or volume.

Uniform Field.—A magnetic field having the same intensity and direction at every point.

Uniform Flux.—Magnetic lines of force which are of the same intensity and direction throughout the magnetic field.

Uniform Load.—In mechanics, a load which is not a variable one and which, therefore, does not induce so great stress as the latter.

Uniform Magnetic Field.—A magnetic field of force containing a uniform number of lines of magnetic force throughout its volume.

Uniform Magnetic Flux.—The lines of magnetic force which constitute a uniform magnetic field.

Uniform Magnetization.—The property of a magnet whose magnetic density is uniform throughout its mass.

Uniform Motion.—The motion of a body when it passes over equal spaces in equal times.

Uniperiodic Current.—An alternating current having a uniform periodicity or frequency.

Uniphase.—A term applied to an alternating current of one pressure wave, or a single alternating current, as distinguished from *polyphase* or *multiphase*, applying to two or more alternating currents having a fixed phase difference in the same circuit.

Uniphaser.—An alternating current dynamo that generates a single alternating current, as distinguished from a *polyphaser* that produces more than one pressure wave.

Uniplanar.—Lying in, or confined to, one plane.

Unipolar Armature.—A dynamo armature which does not undergo a reversal of polarity in the course of a complete revolution.

Unipolar Dynamo.—An *acyclic* or *homopolar* dynamo. A form of continuous cur-

rent machine which dispenses with the action of a commutator, the conductors of the armature moving continually in a uniform and uni-directional field so that there are no reversals in the direction of the induced currents, but electromotive forces of constant direction and magnitude are generated. There are two common types of the unipolar machine, the *axial* and the *radial*. In the axial type, the parts are so arranged that the electricity flows in a direction parallel to the axis or shaft of the generator. In the radial type, the currents are radiated from the axis of rotation to the outer periphery in the discs which form the armature conducting circuit.

Unipolar Electric Bath.—In electro-therapeutics, a bath in which only one electrode is applied to the body, the circuit being completed through the water.

Unipolar Induction.—Induction resulting from continuously cutting lines of magnetic force in such a manner that no reversals take place in the direction of the induced currents, as in a unipolar or homopolar dynamo.

Unipolar Magnet.—A name given to a magnet which, though possessing the necessary two poles, is so suspended that one of the poles lies in the axis of suspension, with the result that the magnet acts as if it possessed only one pole.

Unipolar Stimulation.—In electro-therapeutics, the application of a single electrode for stimulating a nerve.

Uni-slot Armature Winding.—A method of winding an alternator armature in which one slot is provided on the armature for each field magnet pole.

Unit Angle.—In circular measure, the angle measured by an arc equal to the radius. It is called the *radian*.

Unit Angular Velocity.—Angular velocity is measured in *radians per second*, or the number of radians or unit angles through which a particle moving in a circular path turns in a second of time.

Unit Difference of Potential.—The unit of *electromotive force*. It is a difference of potential between two points, such that one erg of work has to be done in order to urge a unit of positive electricity from the point at the lower to that which is at the higher potential. This is the C. G. S. unit. The *volt* or *practical* unit is 100,000,000 times as great.

Unit Jar.—A Leyden jar so adjusted that a spark passes whenever the potential difference reaches a definite value. It is used to measure the amount of electricity required to charge a condenser.

Unit Magnetic Pole.—A magnetic pole which, at a distance of one centimeter, repels an equal and similar pole with a force of one dyne; a pole of unit strength.

Unit of Acceleration.—The acceleration which imparts unit velocity in unit time, or one foot per second in one second.

Unit of Activity.—The rate of work when unit current runs under unit electromotive force. The C. G. S. unit of activity is equivalent to one erg per second. The *practical* unit is the *watt* which is equal to 10,000,000 ergs per second, and represents the power due to a current of one ampere flowing under an electromotive force of one volt.

Unit of Capacity.—The capacity of a conductor which requires a charge of one unit of electricity to raise it to unit potential; it is equal to the capacity of an insulated sphere of one centimeter radius.

Unit of Current.—A current of such strength that if it were made to flow round a circuit in the form of a circle of one centimeter radius, the current in an arc of one centimeter would exert a force of one dyne on a unit magnetic pole at the center. The *practical* unit of electric current is the *ampere* which is equal to $\frac{1}{10}$ of this C. G. S. unit, representing that strength of current which is developed in a circuit of one ohm resistance by an electromotive force of one volt.

Unit of Electrical Supply.—The *kilowatt-hour*, called in Great Britain the Board of Trade Unit. It is equal to 1000 watt-hours. The public supply of electricity for lighting and power purposes is usually measured in kilowatt hours.

Unit of Electromotive Force.—The unit difference of potential between two points. It exists when one erg of work has to be done in urging one unit of electricity against that potential difference. The *volt* or *practical* unit of E. M. F. is 100,000,000 times as great as the C. G. S. unit, and represents the E. M. F. which will produce a current of one ampere against a resistance of one ohm.

Unit of Evaporation.—A unit employed in making boiler tests. It is the equiva-

lent evaporation from and at the boiling point, at atmospheric pressure, or as usually expressed, "from and at 212° F." This forms a basis for comparison of boilers working at different pressures, from which their relative evaporative efficiencies per pound of coal may be ascertained. The unit of evaporation is equivalent to 965.7 British thermal units.

Unit of Force.—The *dyne*. It is that force, which, by acting upon a mass of one gram during one second, can impart to it an acceleration of one centimeter per second during every second that the force is maintained.

Unit of Heat.—That which is required to raise 1 lb. of water, at 39 degrees Fahr., 1 degree. If 2 lbs. of water be raised 1 degree, or 1 lb. be raised 2 degrees in temperature, the expenditure of heat is the same in amount, namely, two degrees of heat, and to express the mechanical equivalent of heat, the comparison lies between the unit of heat on the one part, and the unit of work, or foot pound, on the other. The various heat units are as follows:

A French calorie=1 kilogram of water heated 1° C., at or near 4° C.

A pound-calorie unit=1 pound of water heated 1° C., at or near 4° C.

1 French calorie=3.968 B. T. U.=2.2046 pound calories.

1 British thermal unit=.252 French calories=.555 pound calories.

1 pound-calorie=1.8 B. T. U.=.45 French calories.

1 B. T. U.=778 foot-pounds=Joule's mechanical equivalent of heat.

1 Horse power (H. P.)=33,000 foot-pounds per minute.

1 Horse power $= \frac{33000}{778} = 42.42$ B. T. U. per minute.

1 Horse power=42.42×60=2545 B. T. U. per hour.

1 unit of evaporation=965.7 B. T. U.

Unit of Illuminating Power.—The luminous intensity of sources of light is expressed in terms of *candle power*. A new unit called the *international candle* was established by agreement between authorities in Great Britain, France and United States in 1909. It equals 1 pentane, 1 bougie decimale, 1 American candle, 1.11 Hefner unit, 0.104 Carcel. The American unit is maintained by the Bureau of Standards at Washington. For practical purposes, however, standardised incandescent lamps are employed as units.

Unit of Illumination.—The unit generally employed is the *candle meter*. It is the illumination produced by one unit of candle power at a distance of one meter. The *candle-foot* is sometimes used as a unit, being the illumination produced by a unit of candle power at a distance of one foot. One candle foot is equal to 10.764 candle meters.

Unit of Inductance or Self Induction.—The practical unit of electromagnetic inductance is the *henry*. It is equal to 10^9 C. G. S. units of inductance. The self-induction in a circuit is one henry when the induced E. M. F. is one volt, while the inducing current varies at the rate of one ampere per second. When the henry is too large for convenience, the *milli-henry*, or one-thousandth part of a henry, is used.

Unit of Length.—This varies with different vocations or trades. In workshops, the *inch* is the customary unit; with building trades, the *foot;* in civil engineering, the *yard* for roadmaking, and the *chain* for surveying; in navigation, the *fathom* for soundings, the *nautical* or sea mile for distance, the *knot* for speed.

In the metric system the unit is the *meter*, from which other units are derived by multiplying and dividing the meter by multiples of ten. The meter is equivalent to 39.37 inches, or 3.28 feet, or 1.094 yard.

Unit of Light.—The term *candle power* has long been used as the name for the standard unit of light in English speaking countries. The standard candle was a sperm candle consuming 120 grains per hour. The candle has been superseded in modern practice by the Hefner lamp of fixed dimensions burning amyl acetate gas. A new unit, known as the *international candle*, was adopted by the U. S. Bureau of Standards, April 1, 1909, and England and France have come into agreement with this standard. The international candle equals 1 pentane candle, 1 bougie-decimale, 1 American candle, 1.11 Hefner candle, 0.104 Carcel unit. The Hefner light, the German standard, is therefore 0.90 of the new unit.

Unit of Luminous Intensity.—A light source producing unit illumination of a square meter of concentric spherical surface at a radial distance of one meter.

Unit of Magnetic Flux.—A single line of magnetic force is taken as the unit. It has been named the *maxwell*, after James Clerk Maxwell, the English scientist, who propounded the electromagnetic theory of light.

Unit of Magnetic Intensity.—The unit value of flux density or intensity is one line or maxwell per square centimeter of the magnetic area. It is called a *gauss*.

Unit of Magnetic Reluctance.—The reluctance offered by a cubic centimeter of vacuum is taken as a unit. The name for this unit, provisionally adopted by the

American Institute of Electrical Engineers, is *oersted*, in honor of H. C. Oersted, the Danish scientist, who first discovered the relation of magnetism to the electric current.

Unit of Magnetism.—That quantity of magnetism which must be concentrated in an infinitely small pole, so that, when placed at a distance of one centimeter from an exactly similar pole, it repels it with a force of one dyne.

Unit of Magnetomotive Force.—The *gilbert*. It is that value of M. M. F. which will establish one line or maxwell per centimeter cube of air.

Unit of Mass.—In the C. G. S. system of absolute units, the fundamental unit of mass is the *gram*. It is the one-thousandth part of the mass of a standard kept in Paris called the kilogram. For practical purposes the gram is equal to the mass of one cubic centimeter of water at 4° C., or 15.43235 grains. The English practical unit is the *pound* which is equal to 453.6 grams.

Unit of Measure.—For scientific purposes, three fundamental units have been fixed which are universally the same. They are the *centimeter*, the unit of *length;* the *gram*, the unit of *mass;* and the *second*, the unit of *time*. This system of units is known as the C. G. S. system, and from these fundamental units other units are derived.

Unit of Output of Dynamo.—A convenient unit for designating the power which a dynamo is capable of developing is the *kilowatt*. It is equal to 1000 watts or volt-amperes, or 1.34 horsepower. It is the ordinary commercial unit for rating generators.

Unit of Photometric Intensity.—The unit of intensity of a light source. A source of light is of unit illuminating intensity when it produces unit illumination of a square meter of concentric spherical surface at a radial distance of one meter.

Unit of Power.—The unit of *mechanical* rate of working is one *horsepower*, which is equal to that rate of working which, if continued one minute, could raise 33,000 pounds one foot in height, or expend 33,000 foot pounds of energy. The unit of *electrical* rate of working is the *watt*, which is $\frac{1}{746}$ of a horse power. It is the power due to a current of one ampere flowing under an electromotive force of one volt. In practice, however, a larger unit, the *kilowatt* or 1000 watts, is used for convenience.

Unit of Pressure.—1. In electric practice, the term *pressure* is often used for electromotive force. The unit of E. M. F. is the *volt*. It is that E. M. F. which will produce a current of one ampere against a resistance of one ohm.

2. The atmospheric pressure at the sea level, or 14.7 pounds per square inch absolute.

3. A load equal to one avoirdupois pound on a surface of one square inch.

Unit of Quantity.—1. The *electromagnetic* unit is the quantity of electricity which is conveyed by unit current in one second. The practical unit is the *coulomb* which is the quantity delivered by one ampere flowing for one second. It represents that quantity of electricity which will cause the electrolytic deposition of 0.001118 grain of silver.

2. The *electrostatic* unit is the quantity which at a distance of one centimeter repels a similar and equal quantity with a force of one dyne.

Unit of Resistance.—The resistance possessed by a conductor if a current of unit strength flows through it when its ends are kept at unit difference of potential. The practical unit of electrical resistance is the *ohm*. The standard ohm is the resistance offered by a uniform column of pure mercury, one square millimeter in cross section, 106.3 centimeters in length, weighing 14.4521 grains at 0° C.

Unit of Self-induction.—The *henry*, representing the self-induction in a circuit when the induced E. M. F. is one volt while the inducing current varies at the rate of one ampere per second. The *milli-henry*, or one-thousandth part of a henry is often used as a more convenient unit.

Unit of Time.—In the C. G. S. system of units, the fundamental absolute unit of time is the *second*. It is the 86,400th part of a mean solar day. The minute which is 60 times as great is often used as a more convenient unit of time.

Unit of Work.—The C. G. S. unit of work is called the *erg*. It is that work which is done when a force of one dyne is overcome through a distance of one centimeter. It is therefore a unit of energy. The practical unit of electrical energy or work is the *joule*, which is the work done when one ampere flows for one second against a resistance of one ohm, and is equal to ten million ergs or 0.73734 foot-pounds.

Unit Pole.—A magnetic pole which repels an equal and similar pole with a force of one dyne at a distance of one centimeter.

Unit Strength of Pole.—That which repels another similar and equal pole with the force of one dyne when placed at a distance of one centimeter from it; a unit pole, its symbol is *m*.

Unit System.—In an electric station, an arrangement by which the plant is divided into a series of units, each unit comprising a prime mover and generator with its condenser and attendant auxiliary machinery. The switchboard is also divided, a panel being provided with all the necessary switches and instruments for each unit.

Unit Wire.—A unit for calculating electrical conductors. It is a wire one foot long and 0.001 of an inch in diameter. In the metric system, unit wire is one meter long and one millimeter in diameter.

Univalent.—In chemistry, having the valency, or combining power of one unit, as a univalent atom ; monovalent.

Universal.—1. Pertaining to all things, or applicable to every similar thing without exception.

2. Adaptable to any use; unlimited in its application or motion.

Universal Battery System.—In telegraphy, a system in which a number of circuits are connected with one battery so that each circuit receives the same current.

Universal Discharge.—An apparatus for discharging a battery of Leyden jars through any object; it consists of two movable brass arms with universal joints and supported on glass posts; between the knobs terminating the arms the object to be exposed to the shock is supported upon a third insulated post.

Universal Galvanometer Shunt.—A shunt devised by Ayrton and Mather so as to be used with any galvanometer, the coils being arranged so that their relative multiplying powers are always the same whatever the actual resistance of the instrument may be. It is usually known as the *Ayrton* shunt.

Universal Joint.—A contrivance used for joining two shafts or parts of a machine endwise, so that the one may give rotary motion to the other when forming an angle with it, or may move freely in all directions with respect to the other; as, by means of a cross, connecting the two forked ends of the two shafts. When the angle included between the shafts is less than 145° a double joint of the same kind is used.

Universe.—The world; all existing things viewed as constituting one system or whole.

Unmarked End or Pole.—The south pole of a magnet, so called to distinguish it from the north pole which is usually marked for identification.

Unplugging.—Disconnecting resistance coils from a circuit by withdrawing the plugs of the resistance box.

Unsilvering Bath.—A bath for removing the silver coating from an object that has been silver plated.

U Packing.—A hydraulic leather packing having a section resembling the letter U inverted.

Up and Down Working.—A method of telegraphic transmission in which messages are sent alternately from each end of the line.

Up Contact of Switch.—An electrical circuit completed by moving a switch upward.

Up Lines.—In British telegraph practice, a term applied to the lines which lie in the direction towards the chief station of the circuit, as opposed to *down lines*.

Upper Harmonics of Current.—The higher frequencies which may exist in conjunction with a simple periodic current.

Up Side.—In British telegraph practice, a term applied to that side of a circuit towards the principal station, as distinguished from the *down side*.

Uranium.—A rare metallic element found combined in a few mineral substances, especially in pitchblende. It was in experimenting with uranium in 1896, that Becquerel made the first important discovery in the subject of radio-activity by producing the so-called Becquerel rays.

Uranium Rays.—A form of radiation from uranium discovered by Becquerel in 1896, and usually known as *Becquerel rays*. It was found that uranium and all salts containing it, emitted rays that passed through black paper and affected a photo-

graphic plate, and ionised the gas through which they passed. Their action is similar to Roentgen rays though more feeble. This property of ionising air and other gases is known as *radio-activity*.

Urban Telephony.—Telephoning within city limits, as distinguished from long distance telephoning.

U Section.—Material formed by rolling, pressing or casting into a cross section, like the letter U.

Useful Current.—In an alternating current circuit in which the current and E. M. F. are not in phase, the *effective* or *working* component of the current as distinguished from the wattless current. The *useful* current is that component in phase with the impressed voltage.

Useful Life.—The length of time an incandescent lamp will burn before its output of light decreases more than 20%. When a lamp has fallen below 80% of its rated candlepower, it should be replaced with a new one. On this basis, the best modern lamps will give 6000 to 8000 candle hours of useful life.

V.—1. Abbreviation for *volume.*
2. Symbol for electrostatic potential.
3. Symbol for magnetic potential.
4. Symbol for effective value of potential difference.

v.—1. Abbreviation for *volt.*
2. Abbreviation for velocity.
3. Symbol for the instantaneous value of potential difference.
4. Symbol for the velocity representing the ratio between similar electrostatic and electromagnetic units of the C. G. S. system.

V. A.—Abbreviation for *voltaic alternative.*

Vacuo.—In physics, a term used in calculations on the behavior of falling bodies and liquids, by which their velocity is referred to that of a body falling in a vacuum, or *in vacuo.*

Vacuum.—A space from which the air has been expelled to a greater or less degree of exhaustion; a void. Since the lowest pressure that can be produced in nature is that which results from the removal of the atmospheric pressure from a vessel by the creation of a Torricellian vacuum therein, the absolute zero of pressure is 14.7 pounds below the zero of an ordinary pressure gauge, and the absolute pressure is the recorded or gauge pressure plus 14.7 pounds.

Vacuum Gauge.—An instrument resembling a steam gauge in construction, for measuring the unbalanced pressure of the atmosphere upon condensers, etc.

Vacuum Lightning Arrester.—A lightning arrester consisting of a vacuum tube of glass through which a lightning discharge may be grounded.

Vacuum Line.—A line ruled on an indicator diagram below the atmospheric line, at a distance corresponding to 14.7 lbs., on the scale of the spring, thus showing the *absolute vacuum.*

Vacuum Pump.—1. A pump for exhausting the air from a closed chamber or vessel in order to produce a vacuum. Vacuum pumps, are of two chief kinds: (a) *mechanical* pumps, which consist essentially of a smooth-bore cylinder in which a tight fitting piston containing a valve moves up and down, and (b) *mercury* pumps which depend on the production of a vacuum at the top of a barometer tube, by the flow of drops of mercury past a tap connected to the vessel to be exhausted. Mechanical pumps are in general, inefficient for scientific purposes. The mercury pumps, of which the Geissler and Sprengel pumps are the best known, have been long employed in exhausting incandescent lamp bulbs and for similar work. A newer method for lamp bulbs, involves the use of a finely constructed mechanical pump which exhausts the greater part of the air, after which a chemical is introduced to remove the remaining oxygen.

2. A sort of *pulsometer*, in which a vacuum is created by the condensation of steam admitted into the pump chamber; the water which rises into the suction is blown out by a fresh supply of steam, which then condenses, creating the vacuum anew.

The term "vacuum pump" is in general use, but, properly speaking, it should be called an *air pump.*

Vacuum Tube Lamp.—A *vapor tube* lamp, an electric lamp which depends for its operation upon the incandescence of the highly rarefied gas in a vacuum tube when an electric current is passed through it. The *Cooper-Hewitt mercury-vapor lamp* and the *Moore light* are two examples of commercially successful vacuum tube lamps.

Vacuum Tube Electric Lamps.—Partial vacuum tubes known as Geissler's and Crookes' are used as a source of light in which the light is produced by the passage of the electric discharge through the rarefied gas of the tube. In such light there is no combustion and only very little heat.

Tubes five or six feet long, three or four inches in diameter, and of any shape, may be lighted, and shine with a bluish white light, vastly brighter than any have been lighted before. The electric terminals for these tubes are not wires sealed into them, but metallic caps upon their ends. These act inductively upon and through the residual air contained in the hermetically sealed tube.

Vacuum Tubes.—Glass tubes such as Crookes and the X-ray tubes in which exhaustion has been carried to a very high degree, and provided with electrodes for producing the luminous phenomena characteristic of radiant gaseous matter.

Valency.—The combining power of a chemical element indicated by the number of units represented by hydrogen with which it can combine, or which it can replace; quantivalence.

Valve.—A lid or cover to an aperture, so formed as to open a communication in one direction, and close it in the other by lifting, turning, or sliding; thus, the valve of a common pump opens upward to admit the water and closes downward to prevent its return.

Valve Circle.—In steam engineering, the circle on a valve diagram whose diameter is equal to the travel of the valve.

Valve Diagram.—In steam engineering, a diagram by which the position of the slide valve for any position of the piston, may be determined graphically. As a consequence, the relative positions of the valve and piston at the instants of opening, cut off, cushioning, release, may also be determined. There are numerous modes of constructing valve diagrams. Those mostly used in valve motion design are known as the *Bilgram* and the *Zeuner* diagrams.

Valve, Electric.—A valve controlled by electricity.

Valve Gear.—The mechanism which controls the motion of the valves admitting and exhausting to or from the cylinders of an engine. With a locomotive, a prime necessity is that the gear shall run equally well in either direction, be reversed rapidly, and be suitable for a high rate of speed and correspondingly frequent alterations of motion.

Vapor.—1. Moisture in the air, any light cloudy substance in the air, as, smoke or fumes.

2. In physics, the semi-gaseous state of a substance which is liquid at ordinary temperatures; as, water in the state of saturated steam.

A vapor that is not near the saturation point, behaves like a gas under changes of temperature and pressure, but if it be sufficiently compressed or cooled, it reaches a point where it begins to condense. It then no longer obeys the same laws as a gas, but its pressure cannot be increased by diminishing the size of the vessel containing it, but remains constant, except when the temperature is changed. The only gas that can prevent a liquid evaporating seems to be its own vapor.

Vapor Globe.—A glass globe for protecting an incandescent lamp in explosive atmospheres, as in mines, or in places where there is danger of fracturing the bulb by dripping water.

Vaporization.—The change from the liquid into the gaseous state, either slowly by evaporation from the surface of the liquid, or rapidly by boiling through its mass.

Vapor Tube Lamp.—A *vacuum tube* lamp, a form of electric lamp depending upon the luminous properties of rarefied gases or vapor when an electric current is passed through them. Two principal forms of vapor tube lamps have reached successful development; the *Cooper-Hewitt mercury-vapor* lamp in which a column of mercury in a glass tube is brought to incandescence by the passage of an electric current, and the *Moore light* which depends upon the incandescence of rarefied gas, composed largely of air, contained in a glass tube of indefinite length. Vapor tube lamps have a luminous efficiency of 25 or 30 per cent. which is far greater than the best arc or incandescent lamps.

Variable Condenser.—A condenser placed in a box and divided into sections, and provided with switches for cutting the different sections in or out and so varying the capacity; an *adjustable* condenser.

Variable Expansion.—A steam engine is said to have variable expansion when the admission valves are controllable by hand, while the engine is running. Where a separate expansion valve is fitted, it may be effected through shortening its travel by means of a *shifting link*, etc. The Corliss or drop valves of low pressure engines usually have their trips regulable by hand, while Meyer expansion plates, adjustable by a hand wheel on the spindle, are frequently fitted with apparatus for the same purpose.

Variable Inductance.—Inductance in a substance which has a variable permeability.

Variable Period.—A period of adjustment in an electric circuit between the instant when the current begins to flow and that at which it becomes steady.

Variable-ratio Transformer.—A transformer having a variable ratio of transformation.

Variable State.—The state of an electric circuit, especially of a telegraph line or submarine cable, during the variable period of the current which exists from the moment the circuit is closed till the current becomes steady.

Variation.—In alternators or alternating current circuits, the maximum difference in phase of the generated voltage wave from a wave of absolutely constant frequency expressed in electrical degrees (one cycle equals 360°). It may be due to the variation of the prime mover.

Variation, Magnetic.—The *declination*, being the angle between the magnetic meridian and the geographic meridian of a place on the earth's surface. The compass needle comes to rest in the magnetic meridian which is an imaginary line passing through the earth's magnetic poles, but this line does not coincide with the meridian that is described through the geographic poles. The angle measured by this deviation is called the *declination* or *variation*.

Variation Magnetometer.—An instrument for measuring the intensity of the earth's magnetic variation or declination.

Variation Map.—A map or chart of the earth's surface, or any portion of it, with lines drawn connecting the places which have the same *declination* or *magnetic variation*. The lines so drawn are known as *isogonic* or *isogonal lines*.

Variation of Declination.—1. Variations in the declination of the magnetic needle between different points on the earth's surface.

2. The diurnal, annual and secular variations of the magnetic needle at any place.

Variation of Inclination.—Variations in the inclination or dip of the magnetic needle at different localities on the earth's surface.

Variation of Magnetic Needle.—The amount by which a magnetic needle pointing to the earth's magnetic poles deviates from the direction of the geographical north and south. The compass needle rests in the magnetic meridian, and the angle which the direction of the needle makes with the geographical meridian is called the *declination* or *variation of the magnetic needle*. This variation differs at different places, and at the same place at different times. Regular changes are known as *secular*, *annual* or *diurnal* as they occur through long intervals, yearly or daily. Irregular changes exhibit phenomena known as *magnetic storms*.

Variation of Resistance.—The electrical resistance of a conductor of uniform material and cross section varies directly as its length and inversely as its cross section. The resistance of a metallic conductor invariably increases with an increase in temperature, but a non-metallic substance shows the reverse effect. The *specific resistance* of a metal, or the resistance of a unit wire, varies greatly with different metals, the resistance of pure annealed copper being taken as a standard.

Variation of Speed.—A fault in dynamo operation indicated by the dynamo failing to excite, or by a decrease of the voltage if the machine is working. The fault may proceed from a number of causes: 1, Reduced speed of driving engine; 2, overload of dynamo; 3, defective bearings; 4, short circuits in armature; 5, armature rubbing against pole pieces; 6, slack or dirty belt.

Variometer.—An instrument for determining and comparing the horizontal component of terrestrial magnetism at different points on the earth's surface.

Varley Loop Test.—A method of locating a cross or ground in a telephone or telegraph line or other cable by using a Wheatstone's bridge in a loop formed of a good wire and the faulty wire joined at their distant ends. One terminal of the battery is grounded and the other connected to a point on the bridge at the junction of the ratio arms. The rheostat arm then includes the resistance of the rheostat plus the resistance of the fault, while the unknown arm includes the resistance of the good wire plus the resistance of the bad wire beyond the fault. When the bridge is balanced, the unknown resistances may be readily determined by a simple equation.

Varnish.—An insulating varnish is prepared for coating electric coils, which is claimed to be flexible, acid, salt and moisture-proof, not blistering under heat, and possessed of high insulating properties.

Varying Continuous Current.—A continuous current of variable strength.

Varying-speed Motor.—A motor, such as the series motor, in which the speed varies with the load, decreasing as the load increases.

Vector.—Any quantity which has *direction* as well as *magnitude*. Motion, displacement, velocity, acceleration, force, electric current, magnetic flux, lines of force, stresses and strains, flow of heat and fluids; all involve magnitude and direction, and are *vector quantities*. Straight lines of definite length may be used to represent vector quantities, the *length* of the line representing the *magnitude*, and the *inclination* of the line to some axis representing the *direction*. A representation of this kind is called a *vector diagram*. Vector diagrams are now almost universally used to express relationships in alternating current circuits.

Vector Diagram.—A diagram showing combinations and relations of vectors.

Vector Equation.—A mathematical equation involving vectors.

Vector Formula.—A formula expressing relations of vectors.

Vector Sum.—The geometrical sum of vectors.

Velocimeter.—An instrument for measuring velocity or speed, especially of projectiles.

Velocity.—The rate of motion of a moving body considered as the distance passed over in a given time, and expressed in units of length per unit of time.

Velocity of Discharge or Efflux.—The velocity with which a liquid issues from an orifice in a containing vessel.

Velocity of Transmission.—In telegraphy, the speed with which a signal traverses the line.

Velocity Ratio.—The ratio, involving a velocity, which exists between dimensions expressed in electrostatic, and those expressed in electromagnetic, units.

Velograph.—A type of tachometer or speed indicator which makes a permanent record of the speeds and times which it indicates.

Vena Contracta.—A contraction of the diameter of a jet of water escaping from an orifice in a vessel, which takes place at a short distance from the opening owing to the momentum of the particles towards the center of the orifice.

Ventilated Armature.—An armature provided with openings so that a current of air passes through it during rotation, thereby reducing the heat generated by Foucault currents.

Ventilating Fan.—A blowing machine, either of rotary or centrifugal type, used for ventilation.

Ventilating Groove.—A groove provided in an armature core for cooling the armature by admitting currents of air.

Ventilation of Armature.—Ventilation provided in an armature by suitable grooves or openings, so that currents of air may be created for reducing the heat generated by Foucault currents.

Ventilation Duct.—In large armatures, ducts or passages for ventilation, to carry off the heat, are provided in the core by occasionally separating the discs by the insertion of blocks of insulating material.

Verdet's Constant.—In magneto-optics, the angle through which the plane of polarization is rotated when a unit magnetic field acts upon a transparent plate of given material, one centimeter in thickness.

Verdigris.—Copper acetate. Found in the market in the form of dark green crystals showing an acid reaction, or as a neutral bright green powder. It is employed in electroplating for preparing copper and brass baths and for coloring, gilding, etc.

Vermilion.—This is a bright red heavy paint made by heating sulphur and mercury together. Vermilion should always have a coat of varnish for outside work, and should not be mixed with white lead, on account of the sulphur which it contains.

Vernier.—A small movable scale invented by Pierre Vernier in 1631, and used for measuring a fractional part of one of the equal divisions on the graduated *fixed* scale.

The vernier consists in its simplest form of a small sliding scale, the divisions of which differ from those of the fixed primary scale. On the scale of the tool is a line of graduations divided into inches and numbered 0, 1, 2, etc., each inch being divided into ten parts, and each tenth into four parts, making forty divisions to the inch. On the sliding jaw is a line of divisions of twenty-five parts, numbered 0, 5, 10, 15, 20, 25. The twenty-five divisions on the vernier correspond, in extreme length, to twenty-four divisions, or $\frac{24}{40}$ of an inch, on the scale: each division on the vernier is, therefore, $\frac{1}{25}$ of $\frac{1}{40}$ or $\frac{1}{1000}$ of an inch shorter than the corresponding division on the scale.

If the vernier be moved until the line marked 0 on the vernier coincides with that marked on the scale, then the next two lines to the right will differ from each other by $\frac{1}{1000}$ of an inch: and the difference will continue to increase $\frac{1}{1000}$ of an inch for each division, until the line 25 on the vernier coincides with a line on the scale.

Vernier Caliper.—A caliper provided with a vernier for precise measurements. It consists of two L shaped pieces, one sliding on the other. The bar of the main piece is marked to a standard scale, say 40 to the inch, the sliding part is supplied with a vernier scale, 25 of whose gradations correspond to $\frac{24}{40}$ on the main scale. The fine measurement is, therefore, $\frac{1}{25} \times \frac{1}{40} = \frac{1}{1000}$ inch or .001. The sliding part is usually made in two parts for quick setting, being roughly set to size,

the outer slide clamped, and the inner jaw carefully set by a horizontal adjusting screw.

Vernier Compass.—A surveyor's compass whose compass circle, with a vernier attachment, is movable about a common center by turning a tangent screw at the south end of the instrument. It is adapted to retrace the lines of *old surveys* where the variation of the compass has changed.

Vernier Transit.—A surveyor's transit having a vernier attachment to the compass by which the latter may be adjusted to indicate the true instead of the magnetic bearings.

Vertical Component of Earth's Magnetism.—The earth's magnetic force acting upon the compass needle in a vertical direction.

Vertical Galvanometer.—A galvanometer having a needle that swings in a vertical plane upon a horizontal axis; an upright galvanometer.

Vertical Intensity of Earth's Magnetism.—The intensity of the vertical component at any point on the earth's surface.

Vertical Magnetic Needle.—A magnetic needle mounted upon a horizontal axis and deflected in a vertical plane.

Vertical Main.—In a system of electric light wiring in large buildings, supply wires which run to the different floors to supply current to the feeders on each floor. Vertical mains are often called *risers*.

Vertical Voltmeter.—A voltmeter having a needle that swings in a vertical plane upon a horizontal axis.

Vibrate.—1. To move to and fro, or from side to side; as, a pendulum; an elastic rod, or a stretched string, when disturbed from its position of rest; to swing; to oscillate.

2. To have the constituent particles move to and fro, with alternate compression and dilatation of parts; as the air or any elastic body; to quiver.

Vibrating Bell.—A continuous ringing bell which, when once started by the push, continues automatically until the battery is exhausted or some one stops it.

Vibration.—A motion to and fro: an oscillation or swing.

Vibration Frequency.—The number of vibrations in a vibrating body per unit of time.

Vibration Needle.—A device carrying weights for measuring the torsional rigidity of a suspension.

Vibration Period.—The time required to execute a complete cycle of vibrating motion.

Vibrator.—A spring mounted tongue or blade which is actuated by the magnet of an induction coil, and by its vibration or trembling produces a rapid succession of sparks, instead of a single one at the moment of ignition, in an internal combustion engine. This vibrator is generally used in a jump spark, high tension, ignition device.

Vibratory Motion.—In physics, a rapid motion back and forth; especially, the repeated motion of the parts of an elastic solid, or of a fluid of which the normal condition has been disturbed, like the waves.

Vine System of Space Relations.— A system of space relations assuming that an advance, with left to right rotation in the manner of a vine tendril, is positive.

Violle, Jules.—Born 1824; a French physicist, distinguished for his researches concerning the temperature of the sun, and the mechanical equivalent of heat.

Violle.—A standard unit of light adopted at the International Electrical Congress of 1884, but since abandoned as a practical standard because of difficulty of exact reproduction. It was the light emitted normal to the surface of one sq. cm. of molten platinum at its temperature of solidification.

Virgin Iron.—A term applied to iron that has never been magnetized.

Virtual Amperes.—In measuring alternating currents by instruments calibrated by the use of continuous currents, the square root of the mean square value of the current.

Virtual Current.—In an alternating current circuit, the *mean effective* or virtual value of the varying current. It is the square root of the mean square of the instantaneous values of the current, and is equal to .707 times the maximum value of the current. The *virtual amperes.*

Virtual Electromotive Force.—In an alternating current circuit, the *mean effective* or *virtual* value of the varying E. M. F. It represents a constant quantity which would produce the same working effect as the varying quantity. It is the square root of the mean square of the instantaneous values of the E. M. F. and is equal to .707 times the maximum value of the E. M. F. The *virtual volts.*

Virtual Resistance.—1. In an alternating current circuit, the *impedance*, which is the ratio of the impressed E. M. F. to the current. It is that quantity which, when multiplied by the current gives the impressed E. M. F. It is equal to the square root of the sum of the squares of the resistance and reactance, and is measured in ohms.

2. In storage batteries, the total resistance due to all the internal effects within the cell, including internal ohmic resistance, polarisation, increase of ohmic resistance due to movement of gases in the electrolyte, etc.

Virtual Value.—In measuring values of electrical quantities which vary as a sine function, a value equivalent to a constant quantity which would produce the same working effect as the varying quantity. It is equal to the square root of the mean square of the instantaneous values of the varying quantity.

Virtual Velocity.—In higher mechanics, a minute hypothetical displacement, assumed in analysis to facilitate the investigation of statical problems. Strictly speaking, it is not a velocity but a length.

Virtual Volts.—In measuring the pressure of alternating currents by voltmeters calibrated by the use of continuous currents, the square root of the mean square value of the electromotive force.

Vis.—1. Force; power.

2. Physical force.

Viscosity.—The property possessed by liquids of resisting deformation. The idea is also associated with *stickiness*. For purposes of comparison, liquids are usually referred to water as 1; with lubricants, rape oil is taken as a standard. The usual method of measuring viscosities is by measuring the time taken by a known volume of the liquid, at a known temperature, in flowing through an aperture of known form and dimensions under a known pressure. Thus tested, water will flow rapidly, while cylinder oil is very sluggish, and hence possesses great *viscosity*.

Viscous Hysteresis.—When a weak magnetic force is applied to soft iron, the resulting change in the magnetism is not completed instantly. The magnetizing force requires a certain time to produce its full effect. There is a protracted creeping up of the magnetism which goes on long after the magnetic force has become constant. This phenomenon is called *time-lag* or *viscous hysteresis*, and is attributed to a property of the particles of the iron known as *magnetic viscosity*.

Vis Inertiæ.—That property of matter by which it tends when at rest to remain so, and when in motion to continue in motion; *inertia*.

Visual Angle.—An angle formed by the intersection of two lines conceived to be drawn from the extremities of an object to the center of the eye.

Visual Signals.—1. In a telephone switchboard, the use of miniature incandescent lamps as signals for attracting the attention of the operator.

2. Telegraphic signals transmitted by means of light, as in heliography.

3. Telegraphic signals which may be read from a dial, as in needle telegraphy.

Visual Telegraphy.—Any form of transmitting messages over long distances so that the signals may be read by sight, as when in *needle telegraphy* the swinging of the needle indicates the letters of the message, or in the *heliograph* flashes of sunlight are reflected from a mirror in terms of the telegraphic code.

Vis Viva.—In physics, the active or living force of a body or of the particles of which it is composed. It may be taken as the measure of the mass multiplied by the square of the velocity, although some writers take it as half this quantity.

Vitreous.—Consisting of glass; of, pertaining to, or derived from glass; as, a *vitreous substance;* vitric.

Vitreous Electricity.—A term applied to the electricity developed in a glass rod by rubbing it with silk. This electric charge will attract to itself bits of pith or paper which have been repelled from a rod of sealing wax or other resinous substance which had been rubbed with wool or fur. There is thus exhibited two kinds of electricity, *vitreous* or *positive* electricity produced on glass with silk, and *resinous* or *negative* electricity produced on sealing wax with wool.

Vitrics.—This term includes the fused compounds in which silex predominates, such as glass and some of the enamels; in con-

tradistinction to the *ceramics*, in which alumina predominates; such as brick, tiles, pottery and certain of the enamels

Vitrified Clay.—A clay which has been subjected to intense heat so as to receive a glassy surface which renders it absolutely proof against chemical action. It has very high insulating properties which make it very valuable for conduits in underground wiring, being at the same time inexpensive and easily laid.

Vitriol.—1. A name given to *sulphuric acid* or some of its compounds, on account of their glassy appearance in certain states. *Blue vitriol* is hydrous copper sulphate; *green vitriol*, copperas; *red vitriol* is either a sulphate of cobalt or a ferric sulphate; *white vitriol* is hydrated zinc sulphate.

2. In chemistry, a sulphate of any one of certain metals; as, copper, iron, zinc, cobalt; so called on account of the glassy appearance or luster.

Vitrite.—A hard and infusible variety of glass useful for insulating purposes in electrical apparatus.

Volatile.—Easily passing from the liquid into the gaseous state; such as ammonia or ether. Substances which affect the smell with pungent or fragrant odors; as musk, hartshorn and essential oils are called *volatile* substances, because they waste away on exposure to the atmosphere. Alcohol and ether are called *volatile* liquids for a similar reason, and because they easily pass into the state of vapor on the application of heat. On the contrary, gold is a *fixed* substance, because it does not suffer waste, even when exposed to the heat of a furnace; and oils are called *fixed* when they do not evaporate on simple exposure to the atmosphere.

Volatilization, Electric.—The reduction of a substance to vapor through extreme electrical heat.

Volatilization of Carbons.—The reduction to vapor of carbon particles from the tips of the carbon electrodes of an arc lamp, forming a path between them for the passage of the voltaic arc.

Volcanic Lightning.—Lightning flashes that accompany the eruptions of volcanoes.

Volt.—The practical unit of electromotive force or difference of potential, equal to 10^8 absolute electromagnetic units; it is that E. M. F. which will produce a current of one ampere against a resistance of one ohm; that E. M. F. which would charge a condenser of one farad capacity with one coulomb of electricity: an E. M. F. approximately equal to that of a single Daniell cell. It derives its name from Volta, the Italian electrician.

Volta, Alessandro.—Born 1745, died 1827. An Italian physicist, celebrated for his discoveries and inventions in electricity. As professor of physics in Italian universities he devoted himself to electrical experiments, and discoveries of great importance resulted. He proposed a new theory of electricity at variance with the "animal electricity" doctrine of Galvini, suggesting that electric power resided in metals, and operated when they were in contact. In 1775 he invented the electrophorus, a simple form of condenser. He constructed the first absolute electrometer, and in 1800 developed the famous electric "*pile*" which bears his name. The following year Napoleon invited him to Paris to show his experiments with the voltaic pile, and a medal was struck in his honor. He lived to see his work carried on to greater accomplishments by Davy, Oersted and Ampère. He is recognised as the discoverer of current electricity, and in his honor the unit of electromotive force has been named the *volt*.

Volta Effect.—An effect discovered by Ulessandro Volta as follows: If two dissimilar metals are placed in contact and then quickly separated an electric current will flow from one to the other. The effect is greatly increased by submerging both metals in a saline solution.

Voltage.—The electromotive force of a circuit reckoned in volts. The electromotive force (usually abbreviated E. M. F.) is that electric pressure which causes a current to flow in a closed circuit. The practical unit of E. M. F. is the *volt*, which is that E. M. F. that will cause a current of one ampere to flow through a resistance of one ohm. Hence the E. M. F. of a circuit measured in volts is the *voltage* of that circuit. The voltage of a dynamo is the E. M. F. delivered at its terminals. This terminal or external voltage is the basis of calculating the efficiency and capacity of electric generators.

Voltage Drop.—The drop of potential in an electric circuit due to the resistance of the conductor. This loss exists in every circuit. It is directly proportional to the length of the conductor, and inversely proportional to its area of cross section.

Voltaic.—A term formerly applied to electric phenomena produced by the current from primary or voltaic batteries.

Voltaic Alternatives.—In electrotherapeutics, alternating currents derived from a voltaic battery.

Voltaic Arc.—The source of light in an arc lamp; it consists of a bow or arch of brilliant light produced between the points

of carbon rods, which, after being brought into electrical contact and subjected to the passage of an electric current, are drawn a short distance apart; the heat thus produced is so intense that the carbon is disintegrated and vaporized, and the space between the carbon tips becomes filled with carbon particles and vapor, which, being good conductors, carry the current across in an arc of intense light.

Voltaic Battery.—A group of voltaic cells employed in combination as a source of electric energy; a *primary* battery as distinguished from a secondary or storage battery.

Voltaic Cell.—In its simplest form, a vessel containing a liquid, called the electrolyte, into which two dissimilar metals, called electrodes, are immersed; upon one of which the liquid exerts chemical action, so that an electric current is set up through a circuit formed by a metallic contact between the electrodes by means of an external conductor; a primary cell.

Voltaic Circuit.—The path traversed by the electric current generated in a voltaic cell through the external conductors, and back again to the cell.

Voltaic Couple.—The two dissimilar metals which form the electrodes of a voltaic cell.

Voltaic Effect.—The effect of voltaic or current electricity discovered by Volta to result from the contact of dissimilar metals under certain circumstances. This discovery resulted from Galvani's famous frogs' legs experiment. Galvani attributed the muscular twitchings to electricity residing in animal tissue, but Volta more nearly approached the truth when he concluded that the effect was due to the contact of the two metals with which the muscles made connection. This led to the discovery that when a plate of zinc and one of copper are placed in dilute sulphuric acid and joined by a wire, a current of electricity traverses the wire. From this the *voltaic* or *primary* battery was the development.

Voltaic Electricity.—Electricity derived from the action of a voltaic cell; *current electricity.*

Voltaic Electromotive Force.—The difference of potential between the electrodes of a voltaic cell produced by the chemical action of the electrolyte.

Voltaic Elements.—The *electrodes* or metallic elements of a voltaic or primary cell. If a strip of zinc and another of copper be introduced into a dilute solution of sulphuric acid, and the terminals of the two metals be joined by a conducting wire, a flow of *voltaic* or *current* electricity will be set up between the metals through the solution and around the circuit of the wire. These elements are used in pairs, and hence are often known as *voltaic couples.*

Voltaic Heat Cell.—A voltaic cell in which heat serves to produce chemical action in the materials of the cell for generating a current.

Voltaic Pair.—A voltaic *couple,* a pair of dissimilar elements, such as zinc and copper or zinc and carbon which, when dipped into an electrolyte such as a solution of sulphuric acid, will cause a flow of electricity through a wire joining their terminals.

Voltaic Pile.—An early form of battery devised by Volta, consisting of a series of pairs of zinc and copper disks in electrical contact placed on top of one another, each pair being separated from the next by moistened paper acting as a cell. A considerable difference of potential develops between the zinc and copper terminals of the pile, the electromotive force increasing with the number of metallic pairs employed.

Voltaism.—The branch of the science of electricity which treats of the production of currents by the action of a solution upon dissimilar metals immersed in it.

Voltameter.—An electrolytic cell employed as a means of measuring an electric current by the amount of chemical decomposition the current effects in passing through the cell.

Voltametric Law.—The law on which measurement by the voltameter is based, viz.: that the amount of chemical decomposition effected by an electric current passing through a solution is proportional to the quantity of the current.

Volt-ammeter.—The *wattmeter,* an instrument for measuring the watts, or the product of the volts and amperes, in an electric circuit. Wattmeters are generally based upon the Siemens dynamometer which has two coils, one fixed and the other movable, through which the current to be measured is passed in series.

Volt-ampere.—The *watt,* the unit of electric power, being one ampere multiplied by one volt. It is the rate at which work is expended when one ampere flows under

a pressure of one volt. It is equal to one *joule per second*, and is equivalent to $\frac{1}{746}$ of one horse power.

Volta's Condensing Electroscope.—A device by which Volta exhibited the production of electricity by the contact of two dissimilar metals. It consisted of a simple gold leaf electroscope combined with a small condenser. A compound bar of two unlike metals when brought in contact with one of the plates of the condenser, during the course of the experiment, leaves an electric charge which is shown by the divergence of the gold leaves.

Volta's Law.—A law, first stated by Volta, that when a number of metals are in contact in series, the total electromotive force of the extremes of the series is equal to the algebraic sum of the electromotive forces at the several junctions.

Volt-coulomb.—The *joule*, the unit of electrical energy, being one coulomb multiplied by one volt. It is the amount of work done in transferring one coulomb of electricity (an *ampere* maintained for one second) under an electromotive force of one volt. It is equal to 10^7 *ergs*, or absolute units of work.

Volt Indicator.—A *voltmeter*, an instrument for measuring directly in volts the difference in potential between any two points in an electric circuit. The voltmeter is a high resistance ammeter. The chief difference between the two instruments is that while the *ammeter* has a very low resistance so that the current may flow through it with the least possible opposition, the *voltmeter* gives its deflection with a very small current, and its resistance is always high.

Voltmeter.—An instrument of high resistance for measuring differences of potential in volts; it is essentially a current meter, but is so calibrated as not to give the *strength* of the current as an ammeter, but the *electromotive force* which produces the current.

Voltmeter Panel of Switchboard.—A switchboard panel in a central station on which the voltmeters are set up.

Voltmeter Switch.—A switch by means of which a voltmeter may be connected with any desired circuit.

Volume Density.—The quantity of electricity per unit volume at a given point upon a charged body.

Volume Specific Resistance.—The resistance between opposite faces of a unit cube of a substance.

Volume Voltameter.—A voltameter which determines the strength of an electric current by measuring the amount of gas evolved from the solution by the passage of the current; a gas or water voltameter.

Vortex Atom.—According to the vortex theory, a hypothetical ring shaped mass of elementary matter having a constant whirling motion, regarded as the state of every atom in the universe.

Vortex Ring.—A ring having motion in a direct line, moving upward or otherwise, and revolving inwardly upon the axis of its circumference; a round rubber band about a stick, as the band is forced along the stick will rotate inwardly and furnish an example of vortex motion.

Voucher.—1. One who vouches, or gives witness or full attestation to anything.

2. A book, paper or document which serves to *vouch* the truth of accounts, or to confirm and establish facts of any kind; also any acquittance or receipt showing the payment of a debt; as, the merchant's books are his *vouchers* for the correctness of his accounts; notes, bonds, receipts and other writings, are used as *vouchers* in proving facts.

V Point.—A V shaped point; a point formed, as by converging lines.

V Thread.—1. A screw thread formed by means of a sharp pointed tool as contrasted with a square thread.

2. A standard thread for pipes, tubing, etc., with an angle of 60° between the sides.

Vulcabeston.—An insulating compound composed principally of asbestos and vulcanized rubber. It is tough, strong, non-absorbent and heat resisting, and is recognized as one of the standard materials for insulating electrical apparatus.

Vulcanite.—A hard compound produced by heating rubber to a high temperature (175°-200° C.) and mixing it with sulphur. As an insulating material its dielectric strength is very high, but it oxidizes in the air and is affected by oil. It is also called *ebonite* and *hard rubber*.

Vulcanization.—The art or process of imparting new properties to caoutchouc or rubber by causing it to combine with

sulphur through the agency of a high temperature. This may be so done as to leave it soft and elastic, or to harden it into a substance like horn.

Vulcanize.—To combine sulphur with natural rubber in order to prolong the life of its elasticity and to prevent its softening by heat.

Vulcanized Fiber.—A very strong and tough insulating material made from vegetable fiber which has been chemically treated, strongly compressed and vulcanized. Though it absorbs moisture, it is not injured by so doing, and it is insoluble in ordinary solvents. It comes in two grades, *hard* and *flexible*, and is easily machined. It is used for magnet bobbin insulators, and for other work in dry locations, also for lining and insulating machine parts.

Vulcanized Rubber.—A compound formed by heating rubber to a temperature of 120° to 150° C., and mixing it with sulphur. Rubber is thus changed into an elastic but not plastic substance, which is not affected by moderate temperatures and is less liable to deteriorate than untreated rubber. All rubber insulation for electrical purposes is made of vulcanized rubber.

Vulcanizer.—A furnace in which the flasks containing the component parts are exposed to a heat sufficient to combine the *sulphur* and *caoutchouc*, and produce the compound called *vulcanite*.

Vulcanizing Poles.—A method of treating wooden telegraph and other poles to prevent decay, consisting of heating the pole in a closed vessel to a temperature of about 500° F., for the purpose of thoroughly expelling the sap from the wood.

W.—The symbol for *work, electrical energy, watt-hour* or the *joule.*

Wall Anchor.—In erecting, a bar of iron with a plate or foot at right angles to it, built into the thickness of a brick wall; the bar end is spiked to a beam or floor joist, to tie the opposite walls together, the plate or foot being between the thicknesses of brick, or on the outside, secured by nuts or riveting.

Wall Bearing.—1. In machinery, a bearing for receiving a shaft when entering or passing through a wall. It is protected by a cast iron casing, built into the wall, the bottom of which serves as a bed plate for the *plummer block,* the upper part supporting the masonry above.

2. In architecture, that part of a beam, girder or truss which rests on the wall.

Wall Bracket.—1. A lamp bracket attached to a wall.

2. In overhead wiring, a bracket for the support of an insulator against a wall, especially when the wire is to be led into a building.

Wall Plug.—A plug designed to be introduced into a wall socket for the purpose of making electrical connection with the supply wires.

Wall Set.—A telephone set designed to rest against the wall.

Wall Socket.—1. A lamp socket, or receptacle, supported on a wall.

2. Any socket placed in a wall for the purpose of admitting a plug for making electrical connection with supply wires.

Wand, Electric.—A gas lighter containing an electrical device for producing a spark, which is operated by pressing a button in the handle.

Wandering of Electric Spark.—A condenser discharge producing the effect of a spherical spark wandering over the surface of the tin foil, when a fault occurs in the mica plate.

Wanted Station.—A term used in a telephone exchange to designate a station with which a subscriber wants a connection.

Washburn and Moen Wire Gauge.—A wire gauge prepared by the Washburn and Moen Mfg. Co. It is identical with the Roebling gauge. Its dimensions vary from No. 0000 which is equal to .3938 inch to No. 36 equal to .009 inch.

Washer Plate.—In pole line construction, a heavy metal plate buried in the ground to serve as an anchor to a guy wire.

Waste Channel.—In hydraulics, a spillway or channel whereby flood water from a dam or intake, or the surplus water from a waste weir, is conducted to a lower watercourse, or to the tail race.

Waste Field.—The *stray field* or *leakage flux.* That portion of the magnetic field of force which fails to pass through the armature, and hence does not contribute to the generation of current.

Waste Weir.—In water reservoirs, a weir constructed at one side of the impounding dam, for carrying off any surplus waters that may accumulate from the springs or other source of supply.

Watch Case Receiver.—A compact form of telephone receiver resembling a watch case in shape. This type is used in telephone exchanges. The receiver is held constantly at the ear of a switchboard operator by means of a head band, both hands being thus kept free for manipulating the switchboard.

Watchman's Electric Clock or Register.—An electric time detector for recording the time a night watchman arrives at a point in his rounds, and makes or breaks the circuit which operates the register.

Water Battery.—A group of primary cells containing zinc-copper couples in an electrolyte of water. Such a battery may be used in the calibration of electrometers.

Water Box.—A name given to a water rheostat in the form of a wooden box containing metal plates immersed in slightly acidulated water.

Water Cell.—A primary cell consisting of a zinc-copper couple in an electrolyte of water.

Water Cooled.—Gas and gasoline engines are said to be *water cooled* when a water jacket surrounds the cylinders, to carry off the heat of combustion, which, if unchecked would volatilize the lubricant. The circulation is maintained either by a pump or by thermo-syphonic action. Small automobile engines are frequently *air cooled.*

Water Cooled Transformer.—A transformer that is kept cool by maintaining a circulation of water about its coils.

Water Cooling.—A means of carrying off heat from a machine or apparatus by surrounding the parts which are liable to undue rise in temperature by a system of water circulation. In transformer practice, water is often circulated through the coils to lower the temperature.

Water Dropping Accumulator.—An apparatus for exhibiting the electrification of the atmosphere, consisting of a metal can filled with water resting upon an insulated support, and allowed to discharge from an orifice so small that the water breaks away in detached drops which serve to convey electric charges.

Water Gauge.—A boiler fitting used to indicate the height of the water within a boiler. It consists of a glass tube connected with the boiler by brass elbow seatings, at such an elevation that the lower and upper ends of the tube will be the lowest and highest permissible water levels.

Water Glass.—Soluble glass, used as a protective coating for various objects.

Water-Gram-Degree-Centigrade.—The unit of heat known as the *small calorie,* being the amount of heat required to raise the temperature of one gram of water one degree Centigrade.

Water Grate.—When, as in certain steam boilers, to increase the heating surface, hollow water tubes are used for grate bars, the arrangement is termed a *water grate.*

Water Hammer.—A noise resembling the blows of a hammer, caused by the pulsative action of entrained water within a steam pipe. It is very dangerous, pipes being ruptured at bends, etc., by the force of previously condensed water driven against them when steam is admitted.

Water Jet Arrester.—A form of lightning arrester sometimes used in water power electric plants. It may consist either of a jet of water playing upon a conductor connected to the lines, or a column of water contained in an insulated pipe, and connected at one end to the earth and at the other to the line. It affords a better protection against static charges than against lightning because of high resistance.

Water Pipe Resistance.—The resistance offered to the flow of water by the inner surface of a conducting pipe.

Water Power Electric Plant.—A power house for generating electricity, usually for long distance transmission in which the force of falling water is utilized as the source of power; a *hydro-electric* plant.

Waterproof Wire.—An electric conducor protected by a waterproof covering.

Water Rheostat.—A device for absorbing the energy developed in testing dynamos and other electrical apparatus. It consists essentially of a wooden box or barrel containing acidulated water, in which are immersed two metal electrodes which can be adjusted with relation to each other.

Water Tube Boiler.—This term is applied to a class of boilers in which the water is contained in a series of tubes, of comparatively small diameter, which communicate with each other and with a common steam chamber. The flames and hot gases circulate between the tubes and are usually guided by partitions so as to act equally on all portions of the tubes. There are many varieties of this type of boiler.

Water-tube Dead-beat Suspension.—A method of damping the oscillations of a galvanometer by attaching to the needle or mirror a vane of mica which turns against the resistance of water in a glass tube.

Water Voltameter.—A device for measuring an electric current by the amount

of gas liberated by the electrolysis of water performed by the current; also known as *gas voltameter*.

Watt.—The practical unit of electrical power or rate of working, equal to 10^7 ergs per second; it is the power due to a current of one ampere flowing under an electromotive force of one volt; equal approximately, to $\frac{1}{746}$ of one horsepower; the volt-ampere. It derives its name from James Watt, the English engineer. See also *international watt*.

Wattage.—In incandescent electric lighting, the number of watts of electric current consumed by a lamp in order to provide a given candle power of light. The commercial term is *watts per candle*.

Watt Arc.—A voltaic arc in which the electric power expended is measured in watts.

Watt Balance.—An electric balance intended to measure electric power in terms of watts.

Watt Component.—In an alternating current, that component of the current which is in phase with the E. M. F., as distinguished from the *wattless* component which is at right angles to the E. M. F. The watt component is also known variously as the *active, power, working* or *energy* component.

Watt-hour.—A unit of electrical work, equal to a rate of one watt expended for one hour.

Watt-hour Efficiency of Storage Battery.—The ratio of the watt-hours obtained from a storage battery to the watt-hours required to charge it; the *real* or *energy* efficiency as distinguished from the *quantity* or *ampere-hour* efficiency.

Watt-hour Meter.—A meter for determining the amount of electrical power consumed in watt-hours.

Watt, James.—Born 1736, died 1819. A Scottish engineer and inventor, famous for his improvements in the design of the steam engine. While repairing a model of Newcomen's steam engine, he discovered the cause of its waste of power, and he devised the separate condenser and the air pump to remedy the defect (1765). He patented his improved steam engine (1769), and entered into partnership with Matthew Boulton for the manufacture of steam engines, in which he continued for twenty-five years (1775–1800). During that time he introduced many important improvements of his own invention, making use of the expansiveness of steam to obtain the double stroke (1782). He discovered the composition of water (1782) and projected the screw propeller (1784). At his death a national monument to him was erected in Westminster Abbey. The name *watt* was given to the unit of electric power in his honor.

Wattless Component.—In an alternating current, a component of the current in quadrature with the volts so that it fails to contribute to the energy of the current; the *idle* component as distinguished from the *active* or *working* component.

Wattless Current.—In an alternating current, a component in quadrature with the electromotive force so that it fails to contribute to the power of the current; the *idle* current as distinguished from the *working* current.

Wattless Electromotive Force.—In an alternating current, a component of the voltage, which, being in quadrature with the current strength, fails to contribute to the pressure of the current.

Wattmeter.—An electrical instrument designed to measure directly the products of the amperes and volts in a circuit and give its readings in watts, a *volt-ammeter*. In the *dynamometer* type there are two coils, or sets of coils, one of which is fixed and the other movable. The movable coil is connected in the current circuit, and the fixed coil in the pressure circuit, or the reverse. The *induction* type is used on alternating current circuits. In this type, electromagnets are arranged near a vane in which eddy currents are caused to flow which react on the magnetic field, and the record made is proportional to the force of the reaction. A *recording* wattmeter is one that will register the watt-hours expended during an interval of time.

Watt-minute.—A unit of electrical work, equal to a rate of one watt expended for a minute of time.

Watt-second.—A unit of electrical work, equal to a rate of one watt expended for one second of time.

Watts per Candle.—The specific consumption of an electric lamp is its watt consumption per mean spherical candle power. In connection with incandescent lamps the term "watts per candle" is used commercially to denote watts consumed per mean horizontal candle power.

Wave Form of Alternating Current.—If the successive values of the electromotive force of an alternating current generator be plotted on a time base, the resulting curve resembles a series of waves or undulations, and closely follows a *sine curve* in form. In general the E. M. F. curve of an alternator may be assumed to be a sine curve as an average shape.

Wave Length.—In periodic motion taking place in any medium, the *length* of the wave is the distance from any given particle in the medium to the next particle which has similar displacement and motion. In a wave of water the wave length is the distance from crest to crest or from hollow to hollow.

Waves, Electromagnetic.—Waves set up in the universal ether by electromagnetic vibrations, as when an oscillator transmits ether vibrations in wireless telegraphy.

Wave Winding.—A method of arranging the coils upon a drum armature, in which the conductors travel around the armature without turning back until all the coils are connected, thus describing a zigzag or wavy path; also called *series* or *undulatory* winding.

Way Lease, or Leave.—A right of way obtained from a property holder for erecting telegraph poles or other electric appliances across his land or over his buildings.

Way Line.—In telegraphy, a line connecting intermediate stations.

Way Office Cut Out.—In telegraphy, a cut out by means of which a way line may be readily disconnected.

Ways for Dynamo.—Provisions made on a dynamo base for moving the machine a short distance, when required to change its position.

Way Station.—In telegraphy, any intermediate station as distinguished from a terminal station.

Way Traffic.—In telegraphy, communication between way stations.

Wear.—The diminution or lessening of substance occasioned by the use of anything, principally through the slow mutual abrasion of pieces in frictional contact with each other. Machinery parts which are subject to wear are generally provided with means for adjustment, so as to take up the slackness produced.

Weather Contact or Cross.—A leak occurring in an overhead line at the insulators during wet weather, because of the weakening effect of moisture upon the insulation.

Weatherproof Wire.—An electric conductor protected from the weather by a waterproof covering, consisting usually of braided cotton of two or three thicknesses saturated with an insulating compound.

Weber.—A name formerly given to the unit of electric current now known as the *ampere*. The name *weber* has also been proposed for the unit of magnetic pole strength, though never generally adopted.

Weber, Wilhelm Eduard.—Born 1804, died 1891. A German physicist, noted for his researches in magnetism and electricity, and especially for the introduction of the absolute system of electrical units, first adopted in 1881.

Weber's Theory of Magnetism.—The theory that in an unmagnetized iron bar all the constituent atoms are individual molecular atoms lying with their axes in irregular directions; but when a magnetizing force is applied, the molecules tend to become set with their axes pointing in the same direction. It is practically identical with Hughes' theory.

Wedge.—A pair of inclined planes, united by their bases or back to back. If, instead of moving a load on an inclined plane, the plane itself be moved beneath the load, it then becomes a wedge. All cutting and piercing instruments, such as knives, razors, chisels, nails, pins, needles, etc., are wedges.

Wedge Battery.—A battery for a telegraph circuit employing a wedge or plug for making the necessary connections.

Wedge Cut Out.—In a telegraph circuit, a cut out effected by the insertion or withdrawal of a specially designed wedge or plug.

Weeding-out of Harmonics.—In a complex harmonic current, the gradual reduction of the upper harmonics by changing

the frequency until a resonance is obtained with the fundamental frequency.

Weep Hole.—A small hole left for drainage through the masonry of a retaining wall, or of a bridge abutment, etc.

Weight Efficiency of Transformer.—The efficiency of a transformer considered in relation to its dimensions and weight.

Weight of Coal.—The weight of coal in the solid lump is from 70 to 80 pounds per cubic foot for bituminous grades, and from 85 or 90 to 100 pounds per cubic foot for anthracite grades. When broken up in ordinary commercial sizes, however, its weight, *in bulk*, is usually from 50 to 54 pounds per cubic foot for bituminous, and from 53 to 58 pounds per cubic foot, for anthracite. These weights correspond to an allowance of from 42 to 45 cubic feet per ton of 2240 pounds for bituminous grades, and from 39 to 42 cubic feet per ton for anthracite grades. In estimating the capacity of coal bunkers, the above figures are usually taken, varied however, by the size of the lumps of coal.

Weight-per-mile-ohm. — A standard of conductivity used in comparing the relative electrical resistance of various grades of metals used in making wire. It is the weight of a conductor a mile long, and of such uniform cross section as to have a resistance of one ohm. The greater the conductivity, the less is the weight-per-mile-ohm. The weight-per-mile-ohm of pure copper is 859 lbs., that is, a wire one mile long of pure copper and having a resistance of one ohm weighs 859 lbs.

Weight Voltameter.—A voltameter, such as a gas or silver voltameter, in which the amount of chemical change wrought by the electric current is measured by weighing one or more of the products of the electrolysis.

Weir.—A wall or dam across a stream, over the top of which the escaping water flows. The object of placing a weir may be for raising the level or for affording a means of measuring the quantity which passes; in the first case, the impounded water may be led to a mill, a sluice or a fish trap; in the second the mean depth of water flowing over the weir is carefully gauged, and its speed noted by continuous observations. For measuring small streams, a *notched board* is employed, and under the name of *tumbling bay*, its use is very common.

Welded Rail Bond.—A method of joining rails in which bolts are dispensed with, the ends of two rails being firmly welded together by an electric welder specially designed for the purpose.

Welder, Electric.—An apparatus for welding metals by electricity; it consists essentially of an alternator supplying a current of given frequency, a welding transformer for reducing the pressure and increasing the volume of the current and at the same time automatically making the welds, and an apparatus for regulating the current furnished to the transformer.

Welding.—The art or process of incorporating two pieces of wrought metal together while at a white heat, when they are in a plastic or semi-fused condition. The pieces to be welded are *scarfed*, formed into a *bird's mouth*, or else simply *upset* and *butted* together. Large pieces may be *glut welded* by the addition of stick-in pieces on either side of the joint. A variety of fluxes are used, to preserve the metal from forming a film of oxide or to clean the surfaces; of these borax is probably the best.

Welding Converter.—A special type of transformer for use in electric welding. It has two laminated cores, and linked with them a heavy copper casting which is the secondary coil with only one turn. The primary winding of many turns is arranged to lie within the groove of the secondary. Sliding clamps are provided in which the metal to be heated is held. The line pressure may be reduced to one or two volts with proportional increase in volume, which generates great heat in the metal to be welded.

Welding, Electric.—The operation of welding metals together by heating them, while firmly butted together, by an electric current of great volume, and, as the metals soften at the contact faces by the intense heat, squeezing them together and shutting off the current.

Welding of Rails.—A method of joining rails by welding them together, thus doing away with bolted joints.

Welding Transformer.—An alternating current transformer for reducing a current pressure and greatly increasing its volume for purposes of electric welding.

Western Union Wire Joint.—A simple method of joining the ends of two wires so as to be mechanically strong and preserve electric conductivity. It consists in overlapping the ends of the bare wire for a few inches, and then twisting each end around the other wire for a few turns. The strength of this joint unsoldered is from 50 to 55 per cent of the strength of the wire: when soldered it becomes 80 or 90 per cent of the strength of the wire itself. It is also called the *American twist joint.*

Westinghouse, George.—Born 1846. An American inventor, engineer and manufacturer. His first notable invention was a railroad frog (1865), but the same year, a collision of freight trains near Troy, N. Y., drew his attention to the matter of power brakes. The result of his experiments was the invention of the air-brake (1868) which at once proved its great efficiency. In 1869 the Westinghouse Air Brake Co. was formed, and many developments and improvements on the original invention followed. In 1883 Mr. Westinghouse patented a system of railway signaling which is now manufactured by the Union Switch and Signal Co. of Pittsburg, Pa. The Westinghouse Electric Co. was organized in 1886 which grew into the Westinghouse Electric and Manufacturing Co. in 1891, and has made rapid advances in the manufacture of electrical apparatus and machinery, largely invented and developed in its own shops.

Weston Cell.—A standard cell which is superseding the Clark cell on account of its constancy, longer life and freedom from temperature coefficient. The electrodes of the Weston cell are *cadmium amalgam* covered with a layer of cadmium sulphate crystals, and *pure mercury* in contact with a paste of mercurous sulphate, cadmium sulphate crystals and metallic mercury. The electrolyte is a concentrated solution of cadmium sulphate and mercurous sulphate. The E. M. F. of this cell is 1.0186 volts at a temperature between 5° and 26° C.

Weston, Edward.—Born 1850. An American electrician, inventor and manufacturer. In 1875, he established at Newark, N. J., the first factory devoted exclusively to the manufacture of dynamos. He designed and patented many improvements in arc and incandescent lighting. He also invented a series of electric measuring instruments which have received international recognition, and an efficient standard cell which has proved superior to the Clark cell and is rapidly superseding it. He was one of the founders of the American Institute of Electrical Engineers (1884), and became its president in 1888.

w. h.—Abbreviation for *watt-hour*.

w. h. e.—Abbreviation for watt-hour efficiency.

Wheatstone's Balance or Bridge.—An important instrument for determining unknown resistances; it consists essentially of a system of four conductors, suitably joined, forming the arms of the bridge, two of the junctions being connected to the terminals of a battery, and the other two joined by the bridge wire which contains a galvanometer; common forms of Wheatstone's bridge are the *meter* bridge, and the *post-office* bridge.

Wheatstone, Sir Charles.—Born 1802, died 1875. An English physicist and inventor, noted for his discoveries in electromagnetism; he took out the first patent for a magnetic telegraph (1837), and the so-called Wheatstone bridge, though not his invention but that of H. Christy, was brought into general use (1843) by his efforts.

Wheel Brush.—A rotary brush for cleaning surfaces preparatory to electroplating.

Wheel Pit.—In hydraulics, the excavation formed for the reception of a turbine or other water wheel.

Whip.—A name sometimes given to a vibrating contact.

Whirl, Electric.—1. The circular lines of force which are conceived to surround a conductor carrying an electric current.

2. A name sometimes given to the so-called *electric wind mill* or *flyer*. A device consisting of a vane of pointed wires bent at the tips which rotates upon a pivot on the conductor of an electrostatic machine, illustrating the escape of electricity from points and the electric wind set up by the discharge.

Whistling Effect.—A musical sound sometimes heard in a telephone receiver when a carbon transmitter held close by it is suddenly jarred.

White Brass.—An alloy of copper and zinc, with sufficient of the latter, or of nickel, lead, etc., to give it a white color.

White Heat.—An intense degree of heat which causes a substance to become incandescent and emit a white light. In forge work the white heat of iron is from 1300° to 1500° C.

White Metal.—A name given to an alloy of varying composition, into which tin enters largely, used for the bearing surface of journal brasses. Its elastic nature easily accommodates minute inequalities in the journal, and therefore insures more even distribution of the frictional load.

White Pine.—The wood of a tree which is one of the most valuable of the twenty-eight species of pines growing in the United States. It is used for pattern work, building construction, furniture, and fancy work.

White Vitriol.—A term sometimes applied to *zinc sulphate*. In electroplating it is used in the preparation of brass and zinc

baths and for matt pickling. It is also known as *white copperas.*

Whur.—A humming or whirring sound, like that of a body moving rapidly through the air; a *whir.*

Wig-wag Signaling.—A system of visual signaling employed in the army and navy, in which messages are transmitted by the waving of small flags according to code.

Wimshurst Influence Machine.—An electrostatic induction machine consisting of two circular plates of varnished glass carrying numerous sectors of tin foil, and arranged so as to rotate at equal speed in opposite directions, the sectors acting both as carriers and inductors.

Wind.—The current of air passing from a part of the atmosphere which is dense to another part which is relatively less dense, the velocity of its passage being measured by the difference in the two densities.

Windage.—A name sometimes given to the air gap between the surface of a dynamo armature and the pole pieces of the field magnets.

Wind and Water Line.—The region of a telegraph pole just at the surface of the ground, where it is exposed to the action of both air and water, and hence is most susceptible to decay.

Wind, Electric.—At the tip of a charged pointed conductor the density becomes so great that the air surrounding the point becomes electrified by contact and is at once repelled. Unelectrified air takes its place and is repelled in turn. This goes on until so much electricity is carried away from the conductor that not enough remains to electrify the air. During the discharge an *electric wind* or *convection stream* blows from the point. It is caused by the stream of *ions* communicating its momentum to the air.

Winding Diagram.—A method of representing by means of a diagram the relations of windings as they actually appear upon the armature. Different colors are often used for indicating the different circuits or phases in the winding.

Winding Pitch.—In armature winding, the number of slots spanned by the sides of a coil is called the *winding pitch.* It is usually the number nearest to, or next smaller than, the quotient of the number of slots in the armature divided by the number of poles in the field frame.

Windings.—The exciting coils wound upon a dynamo armature or on an electromagnet core.

Winding Space.—The space on an armature, or on the core of an electromagnet, spool or bobbin, provided for the winding of the coils.

Windmill, Electric.—An experimental device for illustrating the escape of electricity from points. It consists of a vane of five or six pointed wires bent at the tips in the same direction, radiating from a center which rests upon a pivot. When mounted upon the conductor of an electrostatic machine, the vane rotates in a direction opposite that of the points. The movement of the vane is due to the repulsion of the electrified air particles near the points and the electricity on the points themselves. The motion of the air is called *electric wind.* This device is also called *electric flyer,* and *electric whirl.*

Windmill Meter.—A variety of thermoelectric current meter in which the heat imparted by the current to the conductor causes a light vane or windmill to revolve, and thereby to operate delicate recording clockwork.

Window Contact.—An electric contact which rings an alarm upon the opening of a window, or upon any tampering with a window in an effort to effect an entrance by it.

Window Tube Insulator.—A tube composed of insulating material for introducing an electric conductor into a building through a window.

Wiped Joint.—A plumber's joint employed in uniting sections of lead cable sheathing, consisting of solder applied by a moleskin or cloth pad over the surface of the junction.

Wipe Spark.—An electric spark produced by the brief contact of one conductor brushing past another.

Wiping Contact.—An electric contact made by the brushing of one conductor past another.

Wire.—1. A metallic conductor in an electric system. Iron and steel wires are often used for telegraph or telephone lines, but copper is always employed for long distance

work. Electric light and power wires are usually of copper. They vary in size from No. 8 to No. 0000 B. & S. gauge, or from ⅛ in. to nearly ½ in. in diameter. Insulated copper wire is used for armature and field magnet coils. German silver wire is suitable for resistance boxes or electrical instruments where a high resistance is required.

2. To install a system of electrical conductors in a building or other circuit.

3. To send a message by telegraph.

Wire Annealing.—Softening a wire by heat after it has been hardened by drawing or by exposure to cold after heating.

Wire Brush.—A collecting brush for the commutator of a dynamo or motor made up of copper wire gauze folded several times into a solid flat strip, with the wires running in an oblique direction so as to prevent fraying out.

Wire Chief.—In a telephone exchange, an official who investigates troubles that occur on the line. The troubles which the wire chief undertakes to remedy, are of four kinds, viz.: (a) the breaking of one or both sides of a circuit, or *open circuit*, (b) the electrical contact of both sides of a circuit, or *short circuits*, (c) the electrical contact of one or both sides of a circuit with the earth, or *grounds*, and (d) the mutual contact of two circuits, or *crosses*.

Wire Core.—A core, as of an electromagnet, composed of a bundle of soft iron wires, instead of being a solid iron mass.

Wired.—Furnished with a complete system of electric conductors, as a building *wired* for electric lighting.

Wire Drum.—In overhead wire construction, a drum or sheave upon which the wire is wound ready for paying-out.

Wire Dynamometer.—A *line* dynamometer, an instrument employed in overhead line construction, in conjunction with a "come-along," to obtain a proper degree of tension in a wire.

Wire Finder.—A dynamometer for the purpose of identifying any one of the separate wires contained in a cable.

Wire Gauge.—1. A gauge for measuring the diameter of round wire according to an arbitrary standard. The *American* or *Brown & Sharpe* (B. & S.) gauge is used almost exclusively in America in electrical work. Other well-known gauges are the *Roebling* gauge used extensively for iron and steel wire, and the *Birmingham* gauge used largely in Great Britain and also in America for wires other than those designed for electrical conductors. The diameters of wires on the B. & S. gauge are obtained from the geometric series in which No. 0000 equals 0.46 inch and No. 36 equals .005 inch.

2. A device for determining the gauge of a wire. It is often in the form of a disc or broad flat ring of sheet steel with notches in the circumference corresponding to the numbers and sizes fixed by that gauge. A more accurate gauge is in the form of a vernier caliper measuring the wire in *mils* or thousandths of an inch.

Wire Gauze.—Wire woven into gauze, having a fine mesh. It is sometimes employed in making steam joints, the gauze being cut to the size and shape of the flanges, and smeared with red or white lead previous to the bolting together of the flanges.

Wire Gauze Brush.—A type of brush for collecting the current from the armature of a direct current generator. It consists of a bundle made up of thin sheets or strips of copper wire gauze. Gauze brushes have largely given place to carbon brushes, as metal contact with the commutator tended to injure the commutator surface.

Wire Grating Polarizer.—A device for polarizing electromagnetic waves, consisting of a grating of parallel wires.

Wire Guard.—A network of wire surrounding the bulb of an incandescent lamp, or globe of an arc lamp, as a protection from injury.

Wire Joint.—Any means of uniting the ends of two wires, as the American twist joint, the Britannia joint, etc.

Wireless Station.—In wireless telegraphy, especially for over sea transmission, the plant, usually situated upon a headland, equipped with electric apparatus and lofty masts carrying aerial wires, for the sending and receiving of electric oscillations to and from other wireless stations.

Wireless Telegraphy.—Radio-telegraphy; a system of telegraphy in which messages are transmitted by means of electromagnetic waves set up by an instrument for generating oscillations at the sending station, passing through free space, and received by a delicate detecting instrument at the receiving station. The surging of electric charges at the spark gap of the transmitting instrument causes the current to ascend the sending mast and flow out into the ether in the form of waves or vortex rings expanding in every direction: the aerial conductor at the receiving station obstructs a portion of these waves which are led into the receiving instrument, by which signals

are sounded. A transmitter key controls the duration of the sparks at the spark gap, hence the waves are sent out in groups corresponding to the dots and dashes of the Morse code.

Wireless Telephony.—*Radio-telephony*, the transmission to a distance of articulate speech through space without wires by means of electromagnetic waves. The success of this system depends upon an oscillation detector of such a character that it is capable of varying the current through a telephone receiver to exactly correspond with the variations of air pressure produced by the voice upon a telephone transmitter at the sending station.

Wire Pliers.—Pliers in which a pair of smooth jaws, circular in section and tapered lengthways, are substituted for the ordinary flat and roughened jaws, their purpose being the bending of wire into small curves and loops.

Wire Rail Bond.—In an electric traction system, short pieces of copper wire riveted into the adjoining ends of two rails for the purpose of effecting good electrical conductivity through the track.

Wire Rope.—A rope made by twisting together small wires.

Wire Rope Socket.—A socket by means of which a wire rope is attached to another part. One plan consists in stranding or opening out the rope within the coned socket and driving in a conical wedge from the opposite end; by this means the strain on the rope tends to tighten the wedge. A better plan is to curve back the various strands within the socket, so as to resemble a mushroom or umbrella. The space is then filled with melted lead or babbitt metal, which secures all. The socket is provided with eyes, male or female threads, according to the proposed connection.

Wire Shade Guard.—A wire netting for the protection of an electric lamp shade.

Wire Terminals.—Metal eye sockets for brazing on or soldering ends of wires to switchboards.

Wire Wound Armature.—A dynamo or motor armature wound with coils of wire, as distinguished from a *bar* armature.

Wire Wrench.—A spanner or key whose shank is made of *twisted wire*, for the sake of lightness, as in a bicyclist's equipment.

Wiring.—1. The fitting or application of wire to any purpose.

2. In electrical work, the putting in place of the various conductors within a building.

3. In electroplating, the suspension of articles in the plating baths, by means of hooks, slings, or baskets of wire.

Wiring for Jump Spark Ignition.—The speed of a dynamo should be the same as that indicated on its name plate, and it should be connected to run clockwise or right handed, when viewed in the direction of the commutator. The wires from the dynamo and battery should be connected to the engine through the switch and primary coil, and the wires from the secondary coil should be connected to the spark plug and the engine. The engine is started by means of the battery, and its operation continued with the current from the dynamo.

The brushes of the dynamo should press firmly on the commutator but not so as to bind, and if at any time the dynamo ceases to generate current, the commutator should be cleaned with a piece of sand paper. When the dynamo is driven by means of a friction pulley, the latter should be arranged to just touch lightly against the fly wheel, as too much pressure tends to destroy the leather. Usually, the dynamo is furnished with a tension spring which serves to press the friction pulley against the fly wheel, thus obviating the necessity for using injurious tightening screws.

Wiring for Make-and-break Ignition.—For make-and-break ignition, the general plan of wiring or connection is the same for both dynamos and magnetos, but it requires some modification in the case of the jump spark. The generator may be placed on a low stand on the floor and connected by belt with the fly wheel, or, if it is to be driven by a friction pulley, it may be placed on some part of the engine frame so that the pulley will just touch the fly wheel when the generator is in the middle position. If the generator be a dynamo, it is usually connected to run right-handed or clockwise, but if it is desired to run it in the opposite direction, this may be accomplished by crossing the leads going to the two brush holders from the field coils. In the case of a magneto, it makes no difference in which direction the armature is revolved. The wires leading from the generator and from the battery should be connected with the engine through the spark coil and the switch.

Engines of three horse power or less do not require batteries for starting, as a few rapid turns of the fly wheel by hand will produce a spark of sufficient intensity to ignite the charge. Engines of more than three horse power usually require starting batteries composed of six or eight dry battery cells.

Wolfram.—A name sometimes given to *tungsten*, a somewhat rare metal employed for the filament in the tungsten incandescent lamp.

Work.—When a force acts upon a body so as to overcome resistance and produce motion, *work* is performed, and the measure of the work is the product of the force

by the distance moved. Work is done when a body is lifted against the force of gravity, when a body is caused to overcome the resistance of friction, etc. The common units of work are the *foot pound* and the *erg*. A foot pound is the work done when a force of one pound acts through a distance of one foot; an erg is the work done by a force of one dyne acting through a distance of one centimeter.

Working Constant.—The galvanometer constant; a calibrating or standardizing quantity applied to a galvanometer for establishing a fixed relation to the currents causing the deflections. It may be generally defined as the number of the divisions of the deflection caused by the current of a certain battery passing through the galvanometer and a resistance of one megohm.

Working Current.—In an alternating current, a component in phase with the electromotive force, thus contributing to the power of the current, as distinguished from the *wattless* or *idle* current. The working component is also variously known as the *active, energy, power* or *watt* component.

Working Efficiency of Telegraph Line.—The variation of the strength of the current at any station when the key at another station is alternately opened and closed. It depends upon the ratio between the resistance of the line and the insulation resistance.

Working Material of Storage Cell.—The *active* material upon the electrodes of a storage cell. It usually consists of *lead peroxide* on the positive plate, and *spongy lead* on the negative plate. When fully charged, the positive plate has a reddish-brown or chocolate color and is hard, while the pure lead of the negative plate is grayish or slate colored and can easily be marked by the finger nail.

Working Position.—The position of a switch when the circuit is closed.

Working Pressure.—The safe working pressure to which a boiler is subjected; this is usually estimated to be one-sixth of the bursting pressure.

This is the *maximum* pressure safe to carry on a boiler consistent with the factor of safety employed in the design; it should not be confused with the *running pressure*, that is, with the pressure ordinarily carried in running the engine. The safety valve is usually set to blow off at the *working pressure*, hence, the *running pressure* of necessity must be lower.

Working Speed.—The speed at which signals can be sent over a telegraph line or cable.

Worm Gear.—Spiral gearing in which a worm or screw is used to rotate a wheel with suitably shaped teeth; a worm wheel; a form of gear sometimes used with electric motors where a considerable amount of speed reduction is required.

Worsteds.—In mechanics, filaments of worsted or wool conducting oil by capillary attraction, from a reservoir into the lubrication ducts of a bearing; used chiefly on marine engines.

Wrapped Wire.—A conductor wrapped in an insulating covering.

Wrench.—A spanner or key for twisting or turning bolts, nuts, pipe or the like; or *adjustable*, to fit a bolt head, or other object to be turned.

Writing Telegraphy.—A system of autograph facsimile telegraphy which records at the receiving station a facsimile of the handwriting of the sender. The principle of operation is that of compounding the movements of a point in two directions, the one at an angle to the other, the actual movement of the point being the resultant of the two movements.

Wrought Iron Pipe.—In steam fitting, a common welded pipe. As listed, the sizes given are nominal inside diameters, the actual diameters being larger; thus, a ⅛ inch pipe has an inside diameter of .4 inch. Pipes from ⅛ inch to 1 inch inclusive, are usually butt welded; those of standard thickness are tested to 300 lbs. per sq. in., while the larger sizes are lap welded and tested to 500 lbs. per sq. in. Wrought iron pipes are made in several weights for different pressures. Wrought iron pipe can easily be bent at a red heat, its connections readily made with T's, elbows, crosses and screwed unions and sockets; faulty pipes are seldom found.

X, x.—1. Symbol for *reactance*.
2. In mathematics, x is used to represent an unknown quantity, a variable or ordinate.

X-ray Field.—The field or region within which X-rays are active.

X-ray Fluoroscopy.—Experiments with X-rays upon a fluorescent screen.

X-ray Lamp.—A name sometimes given to the vacuum tube for generating X-rays.

X-ray Photograph.—A photograph in shadows of the interior of bodies opaque to ordinary light, taken by means of the penetration of X-rays; a *radiograph*.

X-ray Photography.—The use of a photographic plate in obtaining a picture of the shadows cast by substances in the path of X-rays, which are opaque to the rays.

X-rays.—*Roentgen* rays; a peculiar radiation possessing remarkable properties discovered by Roentgen in 1895, while experimenting with a highly exhausted Crookes tube. These rays are projected from a target within the tube against which the rays from the cathode are directed, and are found to differ from any form of radiation hitherto known. They pass readily through many substances opaque to light; they act on an ordinary photographic plate; they are incapable of reflection, refraction or polarisation; they produce brilliant fluorescence on certain substances; they render the air a conductor of electricity, and cause painful trouble on the human skin if too long exposed to them.

X-ray Screen.—In radiography, a screen coated with fluorescent material for exhibiting he shadows of substances that are opaque to X-rays. It consists of a sheet of cardboard, or similar material, which has been coated with certain chemical salts which have the power of absorbing light, and of shining afterwards in the dark. Such a screen mounted in a box forms a *fluoroscope*. X-rays passing from a tube through an object will display on the screen images of substances contained in the object that are not transparent to the rays.

X-ray Transformer.—A step up transformer designed to furnish a current of high potential to the electrodes of an X-ray tube.

X-ray Tube.—A Crookes vacuum tube designed to produce Roentgen or X-rays. It consists essentially of an exhausted glass bulb provided with terminals at either end, and a platinum reflector so adjusted that the cathode rays set up at the negative terminal impinge upon it and generate the X-rays.

Xylantrax.—Wood coal, charcoal, or any other coal produced by burning, so called in distinction to *mineral coal*.

Xylonite.—The same as *celluloid*. A mixture of camphor with pyroxylin. The camphor is heated and the pyroxylin added, the whole worked into a mass under rollers, the color being added before working. After this the mass is warm pressed into the desired forms. It is used for fittings, ornaments, and other substitutes of *ivory* and *bone*. The material is highly inflammable, but not explosive.

Y, y.—1. Symbol for *admittance.*

2. A pipe fitting, where two branches unite together to form one, resembling the letter Y in appearance. The enclosed angle is usually 45°.

Yale Lock Alarm Switch.—A device which will sound an electric alarm if a door be unfastened by any other means than by the proper key.

Yarn.—Cotton yarn is braided or twisted over the surface of electrical conductors usually to serve as a support for varnish or other insulation. When dry, yarn has excellent insulating properties.

Y-connected Armature.—A three phase armature having one end of each of the coils connected to a common junction in a so-called *Y* or *star* connection.

Y-connection.—The principle of the *star* connection applied to a three phase circuit, forming a branching connection suggesting the letter Y.

Y-connector.—A connecting device for a conductor and two branches.

Y-current.—The current passing through one of the branches of a Y-connected three phase system.

Yellow Brass.—An inferior kind of brass formed of an alloy of copper, seventy parts, and zinc, thirty parts. It is used for the commoner class of turned and other work, also for name plates and similar castings where durability and strength are not essential.

Y-guy.—In pole line construction, a form of stay provided for points along the line where bends occur, or where other severe strains are exerted on the poles; it consists of two guy wires attached one above and the other below the center of the stress, and joining in a common stay a short distance above the ground.

Yield Point.—In testing materials, the point at which the stresses and the strains become equal, so that deformation or *permanent set* occurs. The point at which the stresses equal the elasticity of a test piece.

Yoke.—In certain forms of electromagnet, having two straight cores, a piece of soft iron screwed to the cores yoking them together.

Yoke Arbor.—A form of double journal box for pulley spindles, in which a curved branch extending from one bearing to the other on each side of the pulley, serves to protect the belt from being chafed or otherwise injured.

Yoke Electromagnet.—A form of electromagnet built up of two straight cores with a piece of soft iron yoking them together at one end.

Young's Modulus.—The modulus of elasticity. It is the intensity of stress required to strain a bar by an amount equal to its own length, assuming the material to remain perfectly elastic.

Y-potential.—The effective potential difference between a terminal and the neutral point of a three phase circuit.

Y-shaped Spark.—A spark having three branches sometimes seen in the discharge of a condenser through an induction coil.

Z, z.—Symbol for *impedance.*

Zamboni, Giuseppe.—Born 1776, died 1846. An Italian physicist; he developed the dry pile (1812), originally invented (1806) by J. W. Ritter, and brought it into such general use that it has ever since been known by his name.

Zamboni's Dry Pile.—A voltaic pile composed of paper discs silvered or tinned on one side, and on the other side coated with powdered binoxide of manganese, placed on top of one another in a glass tube.

Zeeman Effect.—The modification of the spectrum lines of an incandescent vapor when influenced by a powerful magnetic field. So named from Zeeman, the Dutch scientist who discovered it.

Zeeman, Pieter.—Born 1865. A Dutch physicist, discoverer of the phenomenon called the Zeeman effect (1897) produced by the influence of a magnetic field upon the spectra of gases; a discovery leading to new theories as to the nature of the particles which constitute matter, and of the ultimate cause of the ether vibrations which produce light.

Zenith.—That point in the visible celestial hemisphere which is directly above the spectator; the point of the heavens just overhead; opposed to *nadir.*

Zero.—Cipher; nothing; naught; the point from which the graduation of a scale, as of a thermometer, commences.

Zero, in the thermometers of Celsius and Réaumur, is at the point at which water congeals. The zero of Fahrenheit's thermometer is fixed at the point at which the mercury stands when immersed in a mixture of snow and common salt.

Zero Magnet.—A magnet employed in the adjustment of the zero indication of a galvanometer scale.

Zero Method.—An accurate method of obtaining electrical measurements, as with a differential galvanometer or Wheatstone's bridge, in which the unknown resistance is equal to the known when there is no deflection; the *null* method.

Zero Potential.—The potential of the earth's surface taken as an arbitrary zero; so that bodies positively electrified are said to be of a higher potential, and those negatively electrified of a lower potential, than the earth.

Zigzag Alternating Electromotive Force.—An alternating electromotive force which traces a characteristic zigzag curve.

Zigzag Electromotive Force.—An electromotive force tracing a characteristic curve resembling a zigzag line.

Zigzag Lightning.—A form of lightning flash which follows a zigzag path. It is also called *forked* lightning when it splits up into branches.

Zigzag Riveting.—A shop term, in steam boiler construction, used where the rivets are put in a zigzag manner, thus forming double rows; *chain riveting;* also *triple riveting.*

Zinc.—Chemical symbol, Zn. A white metal with a faint bluish tinge. Atomic weight 65.4; melts at 419°; boils at 920°. It is ductile and malleable. It is used in making galvanized iron, and in the preparation of many alloys such as brass, bronze and German silver. It forms the negative pole of nearly all primary cells.

Zinc Bath.—In electroplating with zinc, the solution of zinc sulphate or chloride, or an alkaline solution of zinc, which is subjected to the action of electrolysis.

Zinc Carbon Cell.—A primary cell having electrodes of zinc and carbon, as for example, the Leclanché cell.

Zinc Chloride.—A white crystalline or fused mass which is very soluble and deliquescent. It serves in electroplating for preparing brass and zinc baths, and its

solution is used for nickeling by immersion, soldering, etc. It is also called *hydrochlorate* or *muriate of zinc* and *butter of zinc.*

Zinc-copper Cell.—A primary cell having electrodes of zinc and copper, as for example, the Daniell cell.

Zinc Current.—The negative current derived from the zinc pole of a voltaic cell.

Zincing.—A term sometimes used for *galvanizing.* The process consists merely in dipping iron into melted zinc to obtain a coating of zinc as a protection against rust. The term is also used for the electrodeposition of zinc.

Zincite.—A brittle, translucent mineral of a deep red color, sometimes inclining to yellowish, and consisting chiefly of oxide of zinc, but containing also a small quantity of oxide of manganese, to which its color is supposed to be due; also called *red zinc ore* and *red oxide of zinc.*

Zinc-lead Cell.—A bi-metallic storage cell containing electrodes of zinc and lead in a solution of zinc sulphate. The E. M. F. of this type is high, being about 2.35 to 2.5 volts.

Zinc-mercury Cell.—A primary cell having electrodes of zinc and mercury, as for example, Clark's standard cell.

Zincode.—A term formerly applied to the zinc electrode or cathode of a primary or electrolytic cell.

Zinc Plates.—Slabs of rolled zinc, placed in various positions in the interior of a steam boiler, to prevent corrosion, etc.

Zinc Plating.—Depositing a coating of zinc by the process of electroplating.

Zincs.—Zinc electrodes prepared for use in voltaic cells.

Zinc Sender.—In telegraphy, a device for sending a reverse current momentarily into the circuit after each signal for the purpose of overcoming retardation in the line.

Zinc Sulphate.—White vitriol or white copperas. It forms small colorless prisms of a harsh metallic taste which oxidize on exposure to the air. In electroplating, it is used for the preparation of brass and zinc baths, as well as for matt pickling.

Z-insulator.—A variety of earthenware line wire insulator.

Zircon.—An oxide of zirconium. It is found in certain metamorphic and eruptive rocks and in alluvial deposits.

Zirconium.—A rare metal. Atomic weight 90.6. It melts at about 1500° C. and oxidizes at a very high temperature. It is obtained from zircon by heating with carbon in an electric furnace. It has been experimented with to produce an efficient incandescent lamp filament.

Zirconium-carbon Lamp.—An incandescent lamp developed in Europe, having a filament made by heating an ordinary carbon filament in a vapor of some volatile zirconium compound. This lamp shows a slight advantage over the carbon filament lamp.

Zirconium Lamp.—A type of incandescent lamp employing for its filament hydrides or nitrides of the metal zirconium in combination with some organic binding material. This lamp takes about two watts per candle power. It is of European origin, and has not been adopted in America.

Zircon-wolfram Lamp.—A type of incandescent lamp having a filament made of a mixture of zirconium and tungsten (called "wolfram" in Germany). The lamp has a specific consumption of about 1.4 watts per candle power.

Zodiac.—An imaginary belt in the heavens, 16° or 18° broad, in the middle of which is the *ecliptic,* or sun's path. It comprises the twelve constellations which once constituted, and from which are named, the twelve signs of the zodiac.

Zoetrope.—An optical toy in which figures in different stages of motion are caused to revolve on the inside of a cylinder open at the top and having slits in the side, so that when seen through the slits the figures have the appearance of life.

Zonal Harmonic.—A spherical surface harmonic having all its axes coincident.

Zone.—One of the five great divisions of the earth, with respect to latitude and temperature. They are the *torrid* zone, extending from tropic to tropic 46° 56′, or 23° 28′, on each side of the equator; two *temperate* or *variable* zones, situated between the tropics and polar circles; and two *frigid* zones, situated between the polar circles and the poles.

2. In mathematics, the portion of the surface of a sphere included between two parallel planes.

Zone Lamp.—A lamp provided with a lens arrangement so that all the light rays are projected in a single zone.

Zoömagnetism.—A name sometimes given to so-called animal magnetism, or the power of hypnotism.

HAWKINS' ADDITIONAL AIDS

STANDARDIZATION RULES

OF THE

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GENERAL PLAN.

I. DEFINITIONS AND TECHNICAL DATA.

1 *Note*: The following definitions and classifications are intended to be practically descriptive and not scientifically rigid.

A. DEFINITIONS. CURRENTS.

2 A DIRECT CURRENT is a unidirectional current.

3 A CONTINUOUS CURRENT is a steady, or non-pulsating, direct current.

4 A PULSATING CURRENT is a current equivalent to the superposition of an alternating current upon a continuous current.

5 An ALTERNATING CURRENT is a current which, when plotted, consists of half-waves of equal area in successively opposite directions from the zero line.

6 An OSCILLATING CURRENT is a current alternating in direction, and of decreasing amplitude.

B. DEFINITIONS. ROTATING MACHINES.

7 A GENERATOR transforms mechanical power into electrical power.

8 A DIRECT-CURRENT GENERATOR produces a direct current that may or may not be continuous.

9 An ALTERNATOR or ALTERNATING-CURRENT GENERATOR produces alternating current, either single-phase or polyphase.

10 A POLYPHASE GENERATOR produces currents differing symmetrically in phase: such as two-phase currents, in which the terminal voltages on the two circuits differ in phase by 90 degrees; or three-phase currents, in which the terminal voltages on the three circuits differ in phase by 120 degrees.

11 A DOUBLE-CURRENT GENERATOR produces both direct and alternating currents.

12 A MOTOR transforms electrical into mechanical power.

13 A BOOSTER is a machine inserted in series in a circuit to change its voltage. It may be driven by an electric motor (in which case it is termed a motor-booster) or otherwise.

14 A MOTOR-GENERATOR is a transforming device consisting of a motor mechanically connected to one or more generators.

15 A DYNAMOTOR is a transforming device combining both motor and generator action in one magnetic field, with two armatures; or with an armature having two separate windings and independent commutators.

16 A CONVERTER is a machine employing mechanical rotation in changing electrical energy from one form into another. A converter may belong to either of several types, as follows:

17 *a*. A DIRECT-CURRENT CONVERTER converts from a direct current to a direct current.

18 *b*. A SYNCHRONOUS CONVERTER (commonly called a rotary converter) converts from an alternating to a direct current, or *vice versa*.

19 *c*. A MOTOR-CONVERTER is a combination of an induction motor with a synchronous converter, the secondary of the former feeding the armature of the latter with current at some frequency other than the impressed frequency; *i.e.*, it is a synchronous converter concatenated with an induction motor.

20 *d*. A FREQUENCY-CONVERTER converts from an alternating-current system of one frequency to an alternating-current system of another frequency, with or without a change in the number of phases or in voltages.

21 *e*. A ROTARY PHASE CONVERTER converts from an alternating-current system of one or more phases to an alternating-current system of a different number of phases, but of the same frequency.

C. DEFINITIONS. STATIONARY INDUCTION APPARATUS.

22 STATIONARY INDUCTION APPARATUS change electric energy to electric energy through the medium of magnetic energy. They comprise several forms, distinguished as follows:
23 *a.* In TRANSFORMERS the primary and secondary windings are insulated from one another.
24 *b.* In AUTO-TRANSFORMERS, also called compensators, a part of the primary winding is used as a secondary winding, or conversely.
25 *c.* In POTENTIAL REGULATORS a coil is in shunt and a coil is in series with the circuit, so arranged that the ratio of transformation between them is variable at will. They are of the following three classes:
26 (*a*) COMPENSATOR POTENTIAL REGULATORS in which a number of turns of one of the coils are adjustable.
27 (*b*) INDUCTION POTENTIAL REGULATORS in which the relative positions of the primary and secondary coils are adjustable.
28 (*c*) MAGNETO POTENTIAL REGULATORS in which the direction of the magnetic flux with respect to the coils is adjustable.
29 *d.* REACTORS, or REACTANCE COILS, formerly called choking coils, are a form of stationary induction apparatus used to produce reactance or phase displacement.

D. GENERAL CLASSIFICATION OF APPARATUS.

30 COMMUTATING MACHINES. Under this head may be classed the following: Direct-current generators; direct-current motors; direct-current boosters; motor-generators; dynamotors; converters, compensators or balancers; closed-coil arc machines, and alternating-current commutating motors.
31 Commutating machines may be further classified as follows:
32 *a.* DIRECT-CURRENT COMMUTATING MACHINES, which comprise a magnetic field of constant polarity, a closed-coil armature, and a multisegmental commutator connected therewith.
33 *b.* ALTERNATING-CURRENT COMMUTATING MACHINES, which comprise a magnetic field of alternating polarity, a closed-coil armature, and a multisegmental commutator connected therewith.
34 *c.* SYNCHRONOUS COMMUTATING MACHINES, which comprise synchronous converters, motor converters and double-current generators.
35 SYNCHRONOUS MACHINES, which comprise a constant magnetic field, and an armature receiving or delivering alternating-currents in synchronism with the motion of the machine; *i.e.*, having a frequency equal to the product of the number of pairs of poles and the speed of the machine in revolutions per second.
36 STATIONARY INDUCTION APPARATUS, which include transformers, autotransformers, potential regulators, and reactors or reactance coils.
37 ROTARY INDUCTION APPARATUS, or INDUCTION MACHINES, which include apparatus wherein the primary and secondary windings rotate with respect to each other; *i.e.*, induction motors, induction generators, frequency converters, and rotary phase converters.
38 UNIPOLAR or ACYCLIC MACHINES, in which the voltage generated in the active conductors maintains the same direction with respect to those conductors.
39 RECTIFYING APPARATUS, PULSATING-CURRENT GENERATORS.
40 ELECTROSTATIC APPARATUS, such as condensers, etc.
41 ELECTROCHEMICAL APPARATUS, such as batteries, etc.
42 ELECTROTHERMAL APPARATUS, such as rheostats, heaters, etc.
43 PROTECTIVE APPARATUS, such as fuses, lightning arresters, etc.
44 LUMINOUS SOURCES.

E. MOTORS. SPEED CLASSIFICATION.

45 MOTORS may, for convenience, be classified with reference to their speed characteristics as follows:
46 *a.* CONSTANT-SPEED MOTORS, in which the speed is either constant or does not materially vary; such as synchronous motors, induction motors with small slip, and ordinary direct-current shunt motors.

47 *b*. MULTISPEED MOTORS (two-speed, three-speed, etc.), which can be operated at any one of several distinct speeds, these speeds being practically independent of the load, such as motors with two armature windings.

48 *c*. ADJUSTABLE-SPEED MOTORS, in which the speed can be varied gradually over a considerable range; but when once adjusted remains practically unaffected by the load, such as shunt motors designed for a considerable range of field variation.

49 *d*. VARYING-SPEED MOTORS, or motors in which the speed varies with the load, decreasing when the load increases; such as series motors.

F. DEFINITION AND EXPLANATION OF TERMS.

(I) *LOAD FACTOR.*

50 The LOAD FACTOR of a machine, plant or system is the ratio of the average power to the maximum power during a certain period of time. The average power is taken over a certain interval of time, such as a day or a year, and the maximum is taken over a short interval of the maximum load within that interval.

51 In each case the interval of maximum load should be definitely specified. The proper interval is usually dependent upon local conditions and upon the purpose for which load factor is to be determined.

(II) *NON-INDUCTIVE LOAD AND INDUCTIVE LOAD.*

52 A non-inductive load is a load in which the current is in phase with the voltage across the load.

53 An inductive load is a load in which the current lags behind the voltage across the load. A load in which the current leads the voltage across the load is sometimes called an anti-inductive load.

(III) *POWER-FACTOR AND REACTIVE FACTOR.*

54 The POWER-FACTOR in alternating-current circuits or apparatus is the ratio of the electric power in watts to the apparent power in volt-amperes. It may be expressed as follows:

$$\frac{\text{true power}}{\text{apparent power}} = \frac{\text{watts}}{\text{volt-amperes}} = \frac{\text{energy current}}{\text{total current}} = \frac{\text{energy voltage}}{\text{total voltage}}$$

55 The REACTIVE FACTOR is the ratio of the wattless volt-amperes (*i.e.*, the product of the wattless component of current by voltage, or wattless component of voltage by current) to the total amperes. It may be expressed as follows:

$$\frac{\text{wattless volt-amperes}}{\text{total volt-amperes}} = \frac{\text{wattless current}}{\text{total current}} = \frac{\text{wattless voltage}}{\text{total voltage}}$$

56 POWER-FACTOR and REACTIVE FACTOR are related as follows:
If p = power-factor, q = reactive-factor, then with sine waves of voltage and current,

$$p^2+q^2=1$$

With distorted waves of voltage and current,

$$p^2+q^2 = \text{or} < 1$$

(IV) *SATURATION-FACTOR.*

57 The SATURATION-FACTOR of a machine is the ratio of a small percentage increase in field excitation to the corresponding percentage increase in voltage thereby produced. The saturation factor is, therefore, a criterion of the degree of saturation attained in the magnetic circuits at any excitation selected. Unless otherwise specified, however, the saturation factor of a machine refers to the excitation existing at normal rated speed and voltage. It is determined from measurements of saturation made on open circuit at rated speed.

58 The PERCENTAGE OF SATURATION of a machine at any excitation may be found from its saturation curve of generated voltage as ordinates, against

excitation as abscissas, by drawing a tangent to the curve at the ordinate corresponding to the assigned excitation, and extending the tangent to intercept the axis of ordinates drawn through the origin. The ratio of the intercept on this axis to the ordinate at the assigned excitation, when expressed in percentage, is the percentage of saturation and is independent of the scale selected for excitation and voltage. This ratio is equal to the reciprocal of the saturation-factor at the same excitation, deducted from unity. Thus, if f be the saturation factor and p the percentage of saturation ratio,

$$p = 1 - \frac{1}{f}$$

(V) *VARIATION AND PULSATION.*

59 The VARIATION IN PRIME MOVERS which do not give an absolutely uniform rate of rotation or speed, as in reciprocating steam engines, is the maximum angular displacement in position of the revolving member expressed in degrees, from the position it would occupy with uniform rotation, and with one revolution taken as 360°.

60 The PULSATION IN PRIME MOVERS is the ratio of the difference between the maximum and minimum velocities in an engine-cycle to the average velocity.

61 The VARIATION IN ALTERNATORS or alternating-current circuits in general is the maximum difference in phase of the generated voltage wave from a wave of absolutely constant frequency, expressed in electrical degrees (one cycle equals 360 degrees) and may be due to the variation of the prime mover.

62 The PULSATION IN ALTERNATORS or alternating-current circuits, in general, is the ratio of the difference between maximum and minimum frequency during an engine cycle to the average frequency.

63 RELATION OF VARIATION in prime mover and alternator.

64 If n = number of pairs of poles, the variation of an alternator is n times the variation of its prime mover, if direct-connected, and n/p times the variation of the prime mover if rigidly connected thereto in the velocity ratio p.

II. PERFORMANCE SPECIFICATIONS AND TESTS.

A. RATING.

65 RATING BY OUTPUT. All electrical apparatus should be rated by output and not by input. Generators, transformers, etc., should be rated by electrical output: motors by mechanical output.

66 RATING IN KILOWATTS. Electrical power should be expressed in kilowatts, except when otherwise specified.

67 APPARENT POWER, KILOVOLT-AMPERES. Apparent power in alternating-current circuits should be expressed in kilovolt-amperes as distinguished from real power in kilowatts. When the power factor is 100 per cent., the apparent power in kilovolt-amperes is equal to the kilowatts.

68 The RATED (FULL-LOAD) CURRENT is that current which, with the rated terminal voltage, gives the rated kilowatts, or the rated kilovolt-amperes. In machines in which the rated voltage differs from the no-load voltage, the rated current should refer to the former.

69 DETERMINATION OF RATED CURRENT. The rated current may be determined as follows: If P = rating in watts, or apparent watts if the power factor be other than 100 per cent., and E = full-load terminal voltage, the rated current per terminal is:

70 $I = \frac{P}{E}$ in a direct-current machine or single-phase alternator.

71 $I = \frac{1}{\sqrt{3}} \frac{P}{E}$ in a three-phase alternator.

72 $I = \frac{1}{2} \frac{P}{E}$ in a two-phase alternator.

73 NORMAL CONDITIONS. The rating of machines or apparatus should be based upon certain normal conditions to be assumed as standard, or to be specified. These conditions include voltage, current, power-factor, frequency, wave shape and speed; or such of them as may apply in each particular case. Performance tests should be made under these standard conditions unless otherwise specified.

74 *a.* POWER FACTOR. Alternating-current apparatus should be rated in kilowatts, at 100 per cent. power factor; *i.e.*, with current in phase with terminal voltage, unless a phase displacement is inherent in the apparatus or is specified. If a power factor other than 100 per cent. is specified, the rating should be expressed in kilovolt-amperes and power factor, at rated load.

75 *b.* WAVE SHAPE. In determining the rating of alternating-current machines or apparatus, a sine wave shape of alternating current and voltage is assumed, except where a distorted wave shape is inherent to the apparatus. See Secs. 79–83.

76 FUSES. The rating of a fuse should be the maximum current which it will continuously carry.

77 CIRCUIT-BREAKERS. The rating of a circuit-breaker should be the maximum current which it is designed to carry continuously.

78 *a.* NOTE. In addition thereto, the maximum current and voltage at which a fuse or a circuit-breaker will open the circuit should be specified. It is to be noted that the behavior of fuses and of circuit-breakers is much influenced by the amount of electric power available on the circuit.

B. WAVE SHAPE.

79 The SINE WAVE should be considered as standard, except where a difference in the wave form from the sinusoidal is inherent in the operation of the apparatus.

80 A MAXIMUM DEVIATION of the wave from sinusoidal shape not exceeding 10 per cent. is permissible, except when otherwise specified.

81 The DEVIATION of wave form from the sinusoidal is measured by determining the form by oscillograph or wave meter, computing therefrom the equivalent sine wave of equal length, superposing the latter upon the observed wave in such a manner as to give least difference, and then dividing the maximum difference at any ordinate by the maximum value of the equivalent sine wave.

82 The EQUIVALENT SINE WAVE is a sine wave having the same frequency and the same effective or r.m.s. (root of mean square) value as the actual wave.

83 NON-SINE WAVES. The phase displacement between two waves which are not sine waves, is that phase displacement between their equivalent sine waves which would give the same average product of instantaneous values as the actual waves; *i.e.*, the same electro-dynamometer reading.

C. EFFICIENCY.

(I) *DEFINITIONS.*

84 The EFFICIENCY of an apparatus is the ratio of its net power output to its gross power input.

85 *a.* NOTE. An exception should be noted in the case of storage batteries or apparatus for storing energy in which the efficiency, unless otherwise qualified, should be understood as the ratio of the energy output to the energy intake in a normal cycle. An exception should also be noted in the case of luminous sources.

86 APPARENT EFFICIENCY. In apparatus in which a phase displacement is inherent to their operation, apparent efficiency should be understood as the ratio of net power output to volt-ampere input.

87 *a.* NOTE. Such apparatus comprise induction motors, reactive synchronous converters, synchronous converters controlling the voltage of an alternating-current system, self-exciting synchronous motors, potential regulators and open magnetic circuit transformers, etc.

88 *b.* NOTE. Since the apparent efficiency of apparatus delivering electric power depends upon the power-factor of the load, the apparent efficiency, unless otherwise specified, should be referred to a load power-factor of unity.

(II) *DETERMINATION OF EFFICIENCY.*

89 METHODS. Efficiency may be determined by either of two methods, viz.: by measurement of input and output; or, by measurement of losses.

90 *a.* METHOD OF INPUT AND OUTPUT. The input and output may both be measured directly. The ratio of the latter to the former is the efficiency.

91 *b.* METHOD BY LOSSES. The losses may be measured either collectively or individually. The total losses may be added to the output to derive the input, or subtracted from the input to derive the output.

92 COMPARISON OF METHODS. The output and input method is preferable with small machines. When, however, as in the case of large machines, it is impracticable to measure the output and input; or when the percentage of power loss is small and the efficiency is nearly unity, the method of determining efficiency by measuring the losses should be followed.

93 ELECTRIC POWER should be measured at the terminals of the apparatus. In tests of polyphase machines, the measurement of power should not be confined to a single circuit but should be extended to all the circuits in order to avoid errors of unbalanced loading.

94 MECHANICAL POWER in machines should be measured at the pulley, gearing, coupling, etc., thus excluding the loss of power in said pulley, gearing or coupling, but including the bearing friction and windage. The magnitude of bearing friction and windage may be considered, with constant speed, as independent of the load. The loss of power in the belt and the increase of bearing friction due to belt tension should be excluded. Where, however, a machine is mounted upon the shaft of a prime mover, in such a manner that it cannot be separated therefrom, the frictional losses in bearings and in windage, which ought, by definition, to be included in determining the efficiency, should be excluded, owing to the practical impossibility of determining them satisfactorily.

95 In AUXILIARY APPARATUS, such as an exciter, the power lost in the auxiliary apparatus should not be charged to the principal machine, but to the plant consisting of principal machine and auxiliary apparatus taken together. The plant efficiency in such cases should be distinguished from the machine efficiency.

96 NORMAL CONDITIONS. Efficiency tests should be made under normal conditions herein set forth and which are to be assumed as standard. These conditions include voltage, current, power-factor, frequency, wave shape, speed and barometric pressure, temperature, or such of them as may apply in each particular case. Performance tests should be made under these standard conditions unless otherwise specified. See Secs. 73-75.

97 *a.* TEMPERATURE. The efficiency of all apparatus, except such as may be intended for intermittent service, should be either measured at, or reduced to, the temperature which the apparatus assumes under continuous operation at rated load, referred to a room temperature of 25° C. See Secs. 267–292.

98 With apparatus intended for intermittent service, the efficiency should be determined at the temperature assumed under specified conditions.

99 *b.* POWER FACTOR. In determining the efficiency of alternating-current apparatus, the electric power should be measured when the current is in phase with the voltage, unless otherwise specified, except when a definite phase difference is inherent in the apparatus, as in induction motors, induction generators, frequency converters, etc.

100 *c.* WAVE SHAPE. In electrical apparatus, the sine wave should be considered as standard, except where a difference in the wave form from the sinusoidal is inherent in the operation of the apparatus. See Secs. 79–83.

(III) *MEASUREMENT OF LOSSES.*

101 LOSSES. The usual sources of losses in electrical apparatus and the methods of determining these losses are as follows:

102 (*A*) BEARING FRICTION AND WINDAGE.

The magnitude of bearing friction and windage (which may be considered as independent of the load) is conveniently measured by driving

the machine from an independent motor, the output of which may be suitably determined. See Sec. 94.

(*B*) Commutator Brush Friction.

103 The magnitude of the commutator brush friction (which may be considered as independent of the load) is determined by measuring the difference in power required for driving the machine with brushes on and with brushes off (the field being unexcited).

(*C*) Collector-Ring Brush Friction.

104 Collector-ring brush friction may be determined in the same manner as commutator brush friction. It is usually negligible.

(*D*) Molecular Magnetic Friction and Eddy Currents.

105 These losses include those due to molecular magnetic friction and eddy currents in iron and copper and other metallic parts, also the losses due to currents in the cross-connections of cross-connected armatures.

106 In Machines these losses should be determined on open circuit and at a voltage equal to the rated voltage $+I\,r$ in a generator, and $-I\,r$ in a motor, where I denotes the current strength and r denotes the internal resistance of the machine. They should be measured at the correct speed and voltage, since they do not usually vary in any definite proportion to the speed or to the voltage.

107 Note. The Total Losses in bearing friction and windage, brush friction, magnetic friction and eddy currents can, in general, be determined by a single measurement by driving the machine with the field excited, either as a motor, or by means of an independent motor.

108 Retardation Method. The no-load iron, friction, and windage losses may be segregated by the Retardation Method, in which the generator should be brought up to full speed (or, if possible, to about 10 per cent. above full speed) as a motor, and, after cutting off the driving power and excitation, frequent readings should be taken of speed and time, as the machine slows down, from which a speed-time curve can be plotted. A second curve should be taken in the same manner, but with full field excitation; from the second curve the iron losses may be found by subtracting the losses found in the first curve.

109 The speed-time curves can be plotted automatically by belting a small separately excited generator (say 1/10 kw.) to the generator shaft and connecting it to a recording voltmeter. When the retardation method is not feasible, the frictional losses in bearings and in windage, which ought, by definition, to be included in determining the efficiency, may be excluded; but this should be expressly stated.

(*E*) Armature-Resistance Loss.

110 This loss may be expressed by $p\,I^2\,r$; where r = resistance of one armature circuit or branch, I = the current in such armature circuit or branch, and p = the number of armature circuits or branches.

(*F*) Commutator Brush and Brush-Contact Resistance Loss.

111 It is desirable to point out that with carbon brushes these losses may be considerable in low-voltage machines.

(*G*) Collector-Ring and Brush-Contact Resistance Loss.

112 This loss is usually negligible, except in machines of extremely low voltage or in unipolar machines.

(*H*) Field Excitation Loss.

113 With separately excited fields, the loss of power in the resistance of the field coils alone should be considered. With either shunt- or series-field windings; however, the loss of power in the accompanying rheostat should also be included, the said rheostat being considered as an essential part of the machine, and not as separate auxiliary apparatus.

114 (*I*) Load Losses.

The load losses may be considered as the difference between the total losses under load and the sum of the losses above specified.

115 *a.* In COMMUTATING MACHINES of small field distortion, the load losses are usually trivial and may, therefore, be neglected. When, however, the field distortion is large, as is shown, for instance, by the necessity for shifting the brushes between no load and full load, or with variations of load, these load losses may be considerable, and should be taken into account. In this case the efficiency may be determined either by input and output measurements, or the load losses may be estimated by the method of Sec. 116.

116 *b.* ESTIMATION OF LOAD LOSSES. While the load losses cannot well be determined individually, they may be considerable and, therefore, their joint influence should be determined by observation. This can be done by operating the machine on short-circuit and at full-load current, that is, by determining what may be called the "short-circuit core loss." With the low field intensity and great lag of current existing in this case, the load losses are usually greatly exaggerated.

117 One-third of the short-circuit core loss may, as an approximation, and in the absence of more accurate information, be assumed as the load loss.

(IV) *EFFICIENCY OF DIFFERENT TYPES OF APPARATUS.*

(*A*) DIRECT-CURRENT COMMUTATING MACHINES.

118 In DIRECT-CURRENT COMMUTATING MACHINES the losses are:

119 *a.* BEARING FRICTION AND WINDAGE. See Measurement of Losses (*A*), Sec. 102.

120 *b.* MOLECULAR MAGNETIC FRICTION AND EDDY CURRENTS. See Measurement of Losses (*L*), Sec. 105.

121 *c.* ARMATURE RESISTANCE LOSSES. See Measurement of Losses (*E*), Sec. 110.

122 *d.* COMMUTATOR BRUSH FRICTION. See Measurement of Losses (*B*), Sec. 103.

123 *e.* COMMUTATOR BRUSH AND BRUSH CONTACT RESISTANCE. See Measurement of Losses (*F*), Sec. 111.

124 *f.* FIELD EXCITATION LOSS. See Measurement of Losses (*H*), Sec. 113.

125 *g.* LOAD LOSSES. See Measurement of Losses (*I*), Sec. 114.

126 NOTE. *b* and *c* are losses in the armature or "armature losses"; *d* and *e* "commutator losses"; *f* "field losses."

(*B*) ALTERNATING-CURRENT COMMUTATING MACHINES.

127 In ALTERNATING-CURRENT COMMUTATING MACHINES, the losses are:

128 *a.* BEARING FRICTION AND WINDAGE. See Measurement of Losses (*A*), Sec. 102.

129 *b.* ROTATION LOSS, measured with the machine at open circuit, the brushes on the commutator, and the field excited by alternating current when driving the machine by a motor.

130 This loss includes molecular magnetic friction, and eddy currents, caused by rotation through the magnetic field, I^2r losses in cross-connections of cross-connected armatures, I^2r and other losses in armature-coils and armature-leads which are short-circuited by the brushes as far as these losses are due to rotation.

131 *c.* ALTERNATING OR TRANSFORMER LOSS. These losses are measured by wattmeter in the field circuit, under the conditions of test *b*. They include molecular magnetic friction and eddy-currents due to the alternation of the magnetic field, I^2r losses in cross-connections of cross-connected armatures, I^2r and other losses in armature coil and commutator leads which are short-circuited by the brushes, as far as these losses are due to the alternation of the magnetic flux.

132 The losses in armature-coils and commutator leads short-circuited by the brushes, can be separated in *b*, and *c*, from the other losses, by running the machine with and without brushes on the commutator.

133 *d.* I^2r LOSS, OTHER LOAD LOSSES in armature and compensating winding and I^2r loss of brushes, measured by wattmeter connected across the armature and compensating winding.

134 *e.* FIELD EXCITATION LOSS. See Measurement of Losses (*H*), Sec. 113.

135 *f.* COMMUTATOR BRUSH-FRICTION. See Measurement of Losses (*B*), Sec. 103.

(*C*) SYNCHRONOUS COMMUTATING MACHINES.

136 1. In DOUBLE-CURRENT GENERATORS, the efficiency of the machine should be determined as a direct-current generator, and also as an alternating-current generator. The two values of efficiency may be different, and should be clearly distinguished.

137 2. In CONVERTERS the losses should be determined when driving the machine by a motor. These losses are:

138 *a*. BEARING FRICTION AND WINDAGE. See Measurement of Losses (*A*), Sec. 102.

139 *b*. MOLECULAR MAGNETIC FRICTION AND EDDY CURRENTS. See Measurement of losses (D) Sec. 105.

140 *c*. ARMATURE RESISTANCE LOSS. This loss in the armature is $q I^2 r$, where I = direct current in armature, r = armature resistance and q, a factor which is equal to 1.47 in single-circuit single-phase, 1.15 in double-circuit single-phase, 0.59 in three-phase, 0.39 in two-phase, and 0.27 in six-phase converters.

141 *d*. COMMUTATOR-BRUSH FRICTION. See Measurement of Losses (*B*), Sec. 103.

142 *e*. COLLECTOR-RING BRUSH FRICTION. See Measurement of Losses (*C*), Sec. 104.

143 *f*. COMMUTATOR-BRUSH AND BRUSH-CONTACT RESISTANCE LOSS. See Measurement of Losses (*F*), Sec. 111.

144 *g*. COLLECTOR-RING BRUSH-CONTACT RESISTANCE LOSS. See Measurement of Losses (*G*), Sec. 112.

145 *h*. FIELD EXCITATION LOSS. See Measurement of Losses (*H*), Sec. 109.

146 *i*. LOAD LOSSES. These can generally be neglected, owing to the absence of field distortion.

147 3. THE EFFICIENCY OF TWO SIMILAR CONVERTERS may be determined by operating one machine as a converter from direct to alternating, and the other as a converter from alternating to direct, connecting the alternating sides together, and measuring the difference between the direct-current input, and the direct-current output. This process may be modified by returning the output of the second machine through two boosters into the first machine and measuring the losses. Another modification is to supply the losses by an alternator between the two machines, using potential regulators.

(*D*) SYNCHRONOUS MACHINES.

148 In SYNCHRONOUS MACHINES the losses are:

149 *a*. BEARING FRICTION AND WINDAGE. See Measurement of Losses (*A*), Sec. 102.

150 *b*. MOLECULAR MAGNETIC FRICTION AND EDDY CURRENTS. See Measurement of Lossess (*D*), Sec. 105.

151 *c*. ARMATURE RESISTANCE LOSS. See Measurement of Losses (*E*), Sec. 110.

152 *d*. COLLECTOR-RING BRUSH FRICTION. See Measurement of Losses (*C*), Sec. 104.

153 *e*. COLLECTOR-RING BRUSH CONTACT RESISTANCE LOSS. See Measurement of Losses (*G*), Sec. 112.

154 *f* FIELD EXCITATION LOSS. See Measurement of Losses (*H*), Sec. 113.

155 *g*. LOAD LOSSES. See Measurement of Losses (*I*), Sec. 114.

(*E*) STATIONARY INDUCTION APPARATUS.

156 In STATIONARY INDUCTION APPARATUS, the losses are:

157 *a*. MOLECULAR MAGNETIC FRICTION AND EDDY CURRENTS measured at open secondary circuit, rated frequency, and at rated voltage — $I r$, where I = rated current, r = resistance of primary circuit.

158 *b*. RESISTANCE LOSSES, the sum of the $I^2 r$ losses in the primary and in the secondary windings of a transformer, or in the two sections of the coil in a compensator or auto-transformer, where I = rated current in the coil or section of coil, and r = resistance.

159 *c*. LOAD LOSSES, *i.e.*, eddy currents in the iron and especially in the copper conductors, caused by the current at rated load. For practical

purposes they may be determined by short-circuiting the secondary of the transformer and impressing upon the primary a voltage sufficient to send rated load current through the transformer. The loss in the transformer under these conditions measured by wattmeter gives the load losses + $I^2 r$ losses in both primary and secondary coils.

160 In CLOSED MAGNETIC CIRCUIT TRANSFORMERS, either of the two circuits may be used as primary when determining the efficiency.

161 In POTENTIAL REGULATORS, the efficiency should be taken at the maximum voltage for which the apparatus is designed, and with non-inductive load, unless otherwise specified.

(*F*) ROTARY INDUCTION APPARATUS, OR INDUCTION MACHINES.

162 In ROTARY INDUCTION APPARATUS, the losses are:

163 *a*. BEARING FRICTION AND WINDAGE. See Measurement of Losses (*A*), Sec. 102.

164 *b*. MOLECULAR MAGNETIC FRICTION AND EDDY CURRENTS in iron, copper and other metallic parts; also $I^2 r$ losses which may exist in multiple-circuit windings. *a* and *b* together are determined by running the motor without load at rated voltage, and measuring the power input.

165 *c*. PRIMARY $I^2 R$ LOSS, which may be determined by measurement of the current and the resistance.

166 *d*. SECONDARY $I^2 R$ LOSS, which may be determined as in the primary. when feasible; otherwise, as in squirrel-cage secondaries, this loss is measured as part of *e*.

167 *e*. LOAD LOSSES; *i.e.*, molecular magnetic friction, and eddy currents in iron, copper, etc., caused by the stray field of primary and secondary currents, and secondary $I^2 R$ loss when undeterminable under (*d*). These losses may for practical purposes be determined by measuring the total power, with the rotor short-circuited at standstill and a current in the primary circuit equal to the primary energy current at full load. The loss in the motor under these conditions may be assumed to be equal to the load losses $+I^2 r$ losses in both primary and secondary coils.

(*G*) UNIPOLAR OR ACYCLIC MACHINES.

168 In UNIPOLAR MACHINES, the losses are:

169 (*a*) BEARING FRICTION AND WINDAGE. See Measurement of Losses (*A*), Sec. 102.

170 (*b*) MOLECULAR MAGNETIC FRICTION AND EDDY CURRENTS. See Measurement of Losses (*E*), Sec. 106.

171 (*c*) ARMATURE RESISTANCE LOSSES. See Measurement of Losses (*E*), Sec. 110.

172 (*d*) COLLECTOR BRUSH FRICTION. See Measurement of Losses (*C*), Sec. 104.

173 (*e*) COLLECTOR BRUSH CONTACT RESISTANCE. See Measurement of Losses (*G*), Sec. 112.

174 (*f*) FIELD-EXCITATION as in Sec. 113. See Measurement of Losses (*H*), Sec. 113.

175 (*g*) LOAD LOSSES. See Measurement of Losses (*I*), Sec. 114.

(*H*) RECTIFYING APPARATUS, PULSATING-CURRENT GENERATORS.

176 THIS DIVISION INCLUDES: open-coil arc machines and mechanical and other rectifiers.

177 In RECTIFIERS the most satisfactory method of determining the efficiency is to measure both electric input and electric output by wattmeter. The input is usually inductive, owing to phase displacement and to wave distortion. For this reason the power factor and the apparent efficiency should also be considered, since the latter may be much lower than the true efficiency. The power consumed by auxiliary devices, such as the synchronous motor or cooling devices, should be included in the electric input.

178 In CONSTANT-CURRENT RECTIFIERS, transforming from constant potential alternating to constant direct current, by means of constant-current transforming devices and rectifying devices, the losses in the transforming devices are to be included in determining the efficiency and have to be

measured when operating the rectifier, since in this case the losses may be greater than when feeding an alternating secondary circuit. In constant-current transforming devices, the load losses may be considerable, and, therefore, should not be neglected.

179 In OPEN COIL ARC MACHINES, the losses are essentially the same as in direct-current (closed coil) commutating machines. In this case, however, the load losses are usually greater, and the efficiency should preferably be measured by input- and output-test, using wattmeters for measuring the output. In alternating-current rectifiers, the output should, in general, be measured by wattmeter and not by voltmeter and ammeter, since owing to pulsation of current and voltage, a considerable discrepancy may exist between watts and volt-amperes. If, however, a direct-current and an alternating-current meter in the rectified circuit (either a voltmeter or an ammeter) give the same reading, the output may be measured by direct-current voltmeter and ammeter. The type of alternating-current instrument here referred to should indicate the effective or root-of-mean-square value and the type of direct-current instrument the arithmetical mean value, which would be zero on an alternating-current circuit.

(*I*) TRANSMISSION LINES.

180 The EFFICIENCY of transmission lines should be measured with non-inductive load at the receiving end, with the rated receiving voltage and frequency, also with sinusoidal impressed wave form, except where expressly specified otherwise, and with the exclusion of transformers or other apparatus at the ends of the line.

(*J*) PHASE-DISPLACING APPARATUS.

181 In APPARATUS PRODUCING PHASE DISPLACEMENT as, for example, synchronous compensators, exciters of induction generators, reactors, condensers, polarization cells, etc., the efficiency should be understood to be the ratio of the volt-amperes minus power loss to the volt-amperes.

182 The EFFICIENCY may be calculated by determining the losses, subtracting them from the volt-amperes, and then dividing the difference by the volt-amperes.

183 In SYNCHRONOUS COMPENSATORS and exciters of induction generators, the determination of losses is the same as in other synchronous machines.

184 In REACTORS the losses are molecular magnetic friction, eddy losses and $I^2 r$ loss. They should be measured by wattmeter. The efficiency of reactors should be determined with a sine wave of impressed voltage except where expressly specified otherwise.

185 In CONDENSERS, the losses are due to dielectic hysteresis and leakage, and should be determined by wattmeter with a sine wave of voltage.

186 In POLARIZATION CELLS, the losses are those due to electric resistivity and a loss in the electrolyte of the nature of chemical hysteresis. These losses may be considerable. They depend upon the frequency, voltage and temperature, and should be determined with a sine wave of impressed voltage, except where expressly specified otherwise.

D. REGULATION.

(I) *DEFINITIONS.*

187 DEFINITION. The regulation of a machine or apparatus in regard to some characteristic quantity (such as terminal voltage, current or speed) is the ratio of the deviation of that quantity from its normal value at rated load to the normal rated load value. The term "regulation," therefore, has the same meaning as the term "inherent regulation," occasionally used.

188 CONSTANT STANDARD. If the characteristic quantity is intended to remain constant (*e.g.*, constant voltage, constant speed, etc.) between rated load and no load, the regulation is the ratio of the maximum variation from the rated load value to the no-load value.

189 VARYING STANDARD. If the characteristic quantity is intended to vary in a definite manner between rated load and no load, the regulation is the ratio of the maximum variation from the specified condition to the normal rated-load value.

190 (*a*) NOTE. If the law of the variation (in voltage, current, speed, etc.) between rated load and no load is not specified, it should be assumed to be a simple linear relation; *i.e.*, one undergoing uniform variation between rated load and no load.

191 (*b*) NOTE. The regulation of an apparatus may, therefore differ according to its qualification for use. Thus, the regulation of a compound-wound generator specified as a constant-potential generator, will be different from that which it possesses when specified as an over-compounded generator.

192 In CONSTANT-POTENTIAL MACHINES, the regulation is the ratio of the maximum difference of terminal voltage from the rated-load value (occurring within the range from rated load to open circuit) to the rated load terminal voltage.

193 In CONSTANT-CURRENT MACHINES, the regulation is the ratio of the maximum difference of current from the rated load value (occurring within the range from rated-load to short-circuit, or minimum limit of operation), to the rated-load current.

194 In CONSTANT-POWER APPARATUS, the regulation is the ratio of maximum difference of power from the rated load value (occurring within the range of operation specified) to the rated power.

195 In CONSTANT-SPEED DIRECT-CURRENT MOTORS and INDUCTION MOTORS the regulation is the ratio of the maximum variation of speed from its rated load value (occurring within the range from rated load to no-load) to the rated load speed.

196 The regulation of an induction motor is, therefore, not identical with the slip of the motor, which is the ratio of the drop in speed from synchronism, to the synchronous speed.

197 In CONSTANT-POTENTIAL TRANSFORMERS, the regulation is the ratio of the rise of secondary terminal voltage from rated non-inductive load to no-load (at constant primary impressed terminal voltage) to the secondary terminal voltage at rated load.

198 In OVER-COMPOUNDED MACHINES, the regulation is the ratio of the maximum difference in voltage from a straight line connecting the no-load and rated-load values of terminal voltage as function of the load current, to the rated-load terminal voltage.

199 In CONVERTERS, DYNAMOTORS, MOTOR-GENERATORS AND FREQUENCY CONVERTERS, the regulation is the ratio of the maximum difference of terminal voltage at the output side from the rated-load voltage, to the rated-load voltage on the output side.

200 In TRANSMISSION LINES, FEEDERS, ETC., the regulation is the ratio of the maximum voltage difference at the receiving end, between rated non-inductive load and no load to the rated-load voltage at the receiving end (with constant voltage impressed upon the sending end).

201 In STEAM ENGINES, the regulation is the ratio of the maximum variation of speed in passing slowly from rated-load to no-load (with constant steam pressure at the throttle) to the rated-load speed. For variation and pulsation see Secs. 59-64.

202 In a HYDRAULIC TURBINE or OTHER WATER-MOTOR, the regulation is the ratio of the maximum variation of speed in passing slowly from rated-load to no-load (at constant head of water; *i.e.*, at constant difference of level between tail race and head race), to the rated-load speed. For variation and pulsation see Secs. 59-64.

203 In a GENERATOR-UNIT, consisting of a generator united with a prime-mover, the regulation should be determined at constant conditions of the prime-mover; *i.e.*, constant steam pressure, head, etc. It includes the inherent speed variations of the prime-mover. For this reason the regulation of a generator-unit is to be distinguished from the regulation of either the prime-mover, or of the generator contained in it, when taken separately.

(II) *CONDITIONS FOR AND TESTS OF REGULATION.*

204 SPEED. The REGULATION OF GENERATORS is to be determined at constant speed, and of alternating apparatus at constant impressed frequency.

205 NON-INDUCTIVE LOAD. In apparatus generating, transforming or trans-

mitting alternating currents, regulation should be understood to refer to non-inductive load, that is, to a load in which the current is in phase with the e.m.f. at the output side of the apparatus, except where expressly specified otherwise.

206 Wave Form. In alternating apparatus receiving electric power, regulation should refer to a sine wave of e.m.f., except where expressly specified otherwise.

207 Excitation. In commutating machines, rectifying machines, and synchronous machines, such as direct-current generators and motors, alternating-current and polyphase generators, the regulation is to be determined under the following conditions:

(1) At constant excitation in separately excited fields.
(2) With constant resistance in shunt-field circuits, and
(3) With constant resistance shunting series-field circuits; *i.e.*, the field adjustment should remain constant, and should be so chosen as to give the required full-load voltage at full-load current.

208 Impedance Ratio. In alternating-current apparatus, in addition to the non-inductive regulation, the impedance ratio of the apparatus should be specified; *i.e.*, the ratio of the voltage consumed by the total internal impedance of the apparatus at full-load current, to its rated full-load voltage. As far as possible, a sinusoidal current should be used.

209 Computation of Regulation. When in synchronous machines the regulation is computed from the terminal voltage and impedance voltage, the exciting ampere-turns corresponding to terminal voltage plus armature-resistance-drop, and the ampere-turns at short-circuit corresponding to the armature-impedance-drop, should be combined vectorially to obtain the resultant ampere-turns, and the corresponding internal e.m.f. should be taken from the saturation curve.

E. INSULATION.

(I) *INSULATION RESISTANCE.*

210 Insulation Resistance is the ohmic resistance offered by an insulating coating, cover, material or support to an impressed voltage, tending to produce a leakage of current through the same.

211 Ohmic Resistance and Dielectric Strength. The ohmic resistance of the insulation is of secondary importance only, as compared with the dielectric strength, or resistance to rupture by high voltage. Since the ohmic resistance of the insulation can be very greatly increased by baking, but the dielectric strength is liable to be weakened thereby, it is preferable to specify a high dielectric strength rather than a high insulation resistance. The high-voltage test for dielectric strength should always be applied.

212 Recommended Value of Resistance. The insulation resistance of complete apparatus should be such that the rated voltage of the apparatus will not send more than $\frac{1}{1,000,000}$ of the rated-load current, at the rated terminal voltage, through the insulation. Where the value found in this way exceeds 1 megohm, it is usually sufficient.

213 Insulation Resistance Tests should, if possible, be made at the pressure for which the apparatus is designed.

(II) *DIELECTRIC STRENGTH.*

(*A*) Test Voltages.

214 Definition. The dielectric strength of an insulating wall, coating, cover or path is measured by the voltage which must be applied to it in order to effect a disruptive discharge through the same.

215 Basis for Determining Test Voltages. The test voltage which should be applied to determine the suitability of insulation for commercial operation is dependent upon the kind and size of the apparatus and its normal operating voltage, upon the nature of the service in which it is to be used, and the severity of the mechanical and electrical stresses to

which it may be subjected. The voltages and other conditions of test which are recommended have been determined as reasonable and proper for the great majority of cases and are proposed for general adoption, except when specific reasons make a modification desirable.

216 CONDITION OF APPARATUS TO BE TESTED. Commercial tests should, in general, be made with the completely assembled apparatus and not with individual parts. The apparatus should be in good condition and high-voltage tests, unless otherwise specified, should be applied before the machine is put into commercial service, and should not be applied when the insulation resistance is low owing to dirt or moisture. High-voltage tests should, in general, be made at the temperature assumed under normal operation. High-voltage tests considerably in excess of the normal voltages to determine whether specifications are fulfilled are admissible on new machines only.

217 POINTS OF APPLICATION OF VOLTAGE. The test voltage should be successively applied between each electric circuit and all other electric circuits including conducting material in the apparatus.

218 The FREQUENCY of the alternating-current test voltage is, in general, immaterial within commercial ranges. When, however, the frequency has an appreciable effect, as in alternating-current apparatus of high voltage and considerable capacity, the rated frequency of the apparatus should be used.

219 TABLE OF TESTING VOLTAGES. The following voltages are recommended for testing all apparatus, lines and cables, by a continued application for one minute. The test should be with alternating voltage having an effective value (or root mean square referred to a sine wave of voltage) given in the table and preferably for tests of alternating apparatus at the normal frequency of the apparatus.

	Rated Terminal Voltage of Circuit.	Rated Output.	Testing Voltage.
220	Not exceeding 400 volts	Under 10 kw	1,000 volts.
	" " "	10 kw. and over	1,500 "
	400 and over, but less than 800 volts	Under 10 kw	1,500 "
	" " " " "	10 kw. and over	2,000 "
	800 " " " 1,200 "	Any	3,500 "
	1,200 " " " 2,500 "	Any	5,000 "
	2,500 " "	Any	Double the normal rated voltages.

221 EXCEPTION.—TRANSFORMERS. Transformers having primary pressures of from 550 to 5,000 volts, the secondaries of which are directly connected to consumption circuits, should have a testing voltage of 10,000 volts, to be applied between the primary and secondary windings, and also between the primary winding and the core.

222 EXCEPTION.—FIELD WINDINGS. The tests for field windings should be based on the rated voltage of the exciter and the rated output of the machine of which the coils are a part. Field windings of synchronous motors and converters, which are to be started by applying alternating current to the armature when the field is not excited and a high voltage is induced in the field windings, should be tested at 5,000 volts.

223 RATED TERMINAL VOLTAGE.—DEFINITION. The rated terminal voltage of circuit in the above table, means the voltage between the conductors of the circuit to which the apparatus to be tested is to be connected,—for instance, in three-phase circuits the delta voltage should be taken. In the following specific cases, the rated terminal voltage of the circuit is to be determined as specified in ascertaining the testing voltage:

224 (a) TRANSFORMERS. The test of the insulation between the primary and secondary windings of transformers, is to be the same as that between the high-voltage windings and core, and both tests should be made simultaneously by connecting the low-tension winding and core together during the test. If a voltage equal to the specified testing voltage be induced in the high-tension winding of a transformer it may be used for insulation tests instead of an independently induced voltage. These tests should be made first with one end and then with the other end of the high-tension winding connected to the low-tension winding and to the core.

225 (*b*) CONSTANT-CURRENT APPARATUS. The testing voltage is to be based upon a rated terminal voltage equal to the maximum voltage which may exist at open or closed circuit.

226 (*c*) APPARATUS IN SERIES. For tests of machines or apparatus to be operated in series, so as to employ the sum of their separate voltages the testing voltage is to be based upon a rated terminal voltage equal to the sum of the separate voltages except where the frames of the machines are separately insulated, both from the ground and from each other, in which case the test for insulation between machines should be based upon the voltage of one machine, and the test between each machine and ground to be based upon the total voltage of the series.

(*B*) METHODS OF TESTING.

227 CLASSES OF TESTS. Tests for dielectric strength cover such a wide range in voltage that the apparatus, methods and precautions which are essential in certain cases do not apply to others. For convenience, the tests will be separated into two classes:

228 CLASS 1. This class includes all apparatus for which the test voltage deos not exceed 10 kilovolts, unless the apparatus is of very large static capacity, *e.g.*, a large cable system. This class also includes all apparatus of small static capacity, such as line insulators, switches and the like, for all test voltages.

229 METHOD OF TEST FOR CLASS 1. The test voltage is to be continuously applied for the prescribed interval,—(one minute unless otherwise specified). The test voltage may be taken from a constant-potential source and applied directly to the apparatus to be tested, or it may be raised gradually as specified for tests under Class 2.

230 CLASS 2. This class includes all apparatus not included in Class 1.

231 METHOD OF TEST FOR CLASS 2. The test voltage is to be raised to the required value smoothly and without sudden large increments and is then to be continuously applied for the prescribed interval,—(one minute, unless otherwise specified), and then gradually decreased.

232 CONDITIONS AND PRECAUTIONS FOR CLASS 1 and CLASS 2. The following apply to all tests:

233 The WAVE SHAPE should be approximately sinusoidal and the apparatus in the testing circuits should not materially distort this wave.

234 The SUPPLY CIRCUIT should have ample current-supply capacity so that the charging current which may be taken by the apparatus under test will not materially alter the wave form nor materially affect the test voltage. The circuit should be free from accidental interruptions.

235 RESISTANCE OR INDUCTANCE in series with the primary of a raising transformer for the purpose of controlling its voltage is liable seriously to affect the wave form, thereby causing the maximum value of the voltage to bear a different and unknown ratio to the root mean square value. This method of voltage adjustment is, therefore, in general, undesirable. It may be noted that if a resistance or inductance is employed to limit the current when burning out a fault, such resistance or inductance should be short circuited during the regular voltage test.

236 The INSULATION under test should be in normal condition as to dryness and the temperature should when possible be that reached in normal service.

237 ADDITIONAL CONDITIONS AND PRECAUTIONS FOR CLASS 2. The following conditions and precautions, in addition to the foregoing, apply to tests of apparatus included in Class 2.

238 SUDDEN INCREMENT OF TESTING VOLTAGE on the apparatus under test should be avoided, particularly at high voltages and with apparatus having considerable capacity, as a momentarily excessive rise in testing voltage will result.

239 SUDDEN VARIATIONS IN TESTING VOLTAGE of the circuit supplying the voltage during the test should be avoided as they are likely to set up injurious oscillation.

240 GOOD CONNECTIONS in the circuits supplying the test voltage are essential in order to prevent injurious high frequency disturbances from being set up. When a heavy current is carried by a small water rheostat,

arcing may occur, causing high-frequency disturbances which should be carefully avoided.

241 TRANSFORMER COILS. In high-tension transformers, the low-tension coil should preferably be connected to the core and to the ground when the high-tension test is being made, in order to avoid the stress from low-tension to core, which would otherwise result through condenser action. The various terminals of each winding of the high-tension transformer under test should be connected together during the test in order to prevent undue stress on the insulation between turns or sections of the winding in case the high-voltage test causes a break-down.

(C) METHODS FOR MEASURING THE TEST VOLTAGE.

242 FOR MEASURING THE TEST VOLTAGE, two instruments are in common use, (1) the spark gap and (2) the voltmeter.

243 1. THE SPARK GAP is ordinarily adjusted so that it will break down with a certain predetermined voltage, and is connected in parallel with the insulation under test. It ensures that the voltage applied to the insulation is not greater than the break-down voltage of the spark gap. A given setting of the spark gap is a measure of one definite voltage, and, as its operation depends upon the maximum value of the voltage wave, it is independent of wave form and is a limit on the maximum stress to which the insulation is subjected. The spark gap is not conveniently adapted for comparatively low voltages.

244 In SPARK-GAP MEASUREMENTS, the spark gap may be set for the required voltage and the auxiliary apparatus adjusted to give a voltage at which this spark gap just breaks down. The spark gap should then be adjusted for, say, 10 per cent. higher voltage, and the auxiliary apparatus again adjusted to give the voltage of the former breakdown, which is to be the assumed voltage for the test. This voltage is to be maintained for the required interval.

245 The SPARK POINTS should consist of new sewing needles, supported axially at the ends of linear conductors which are each at least twice the length of the gap. There should be no extraneous body near the gap within a radius of twice its length. A table of approximate striking distances is given in Appendix D. This table should be used in connection with tests made by the spark-gap methods.

246 A NON-INDUCTIVE RESISTANCE of about one-half ohm per volt should be inserted in series with each terminal of the gap so as to keep the discharge current between the limits of one-quarter ampere and 2 amperes. The purpose of the resistance is to limit the current in order to prevent the surges which might otherwise occur at the time of break-down.

247 2. The VOLTMETER gives a direct reading, and the different values of the voltage can be read during the application and duration of the test. It is suitable for all voltages, and does not introduce disturbances into the test circuit.

248 In VOLTMETER MEASUREMENTS, the voltmeter should, in general, derive its voltage from the high-tension testing circuit either directly or through an auxiliary ratio transformer. It is permissible, however, to measure the voltage at other places,—for example, on the primary of the transformer, provided the ratio of transformation does not materially vary during the test; or that proper account is taken thereof.

249 SPARK GAP AND VOLTMETER. The spark gap may be employed as a check upon the voltmeter used in high-tension tests in order to determine the transformation ratio of the transformer, the variation from the sine wave form and the like. It is also useful in conjunction with voltmeter measurements to limit the stress applied to the insulating material.

(D) APPARATUS FOR SUPPLYING TEST VOLTAGE.

250 The GENERATOR OR CIRCUIT supplying voltage for the test should have ample current carrying capacity, so that the current which may be taken for charging the apparatus to be tested will not materially alter the wave form nor otherwise materially change the voltage.

The TESTING TRANSFORMER should be such that its ratio of transformation does not vary more than 10 per cent. when delivering the charg-

ing current required by the apparatus under test. (This may be determined by short-circuiting the secondary or high voltage winding testing transformer and supplying 1/10 of the primary voltage to the primary under this condition. The primary current that flows under this condition is the maximum which should be permitted in regular dielectric tests.)

251 The VOLTAGE CONTROL may be secured in either of several ways, which, in order of preference, are as follows:

252 1. By generator field circuit.

253 2. By magnetic commutation.

254 3. By change in transformer ratio.

255 4. By resistance or choke coils.

256 In GENERATOR VOLTAGE CONTROL, the voltage of the generator should preferably be about its approximate normal rated-load value when the full testing voltage is attained, which requires that the ratio of the raising transformer be such that the full testing voltage is reached when the generator voltage is normal. This avoids the instability in the generator which may occur if a considerable leading current is taken from it when it has low voltage and low field current.

257 In MAGNETIC COMMUTATION, the control is effected by shunting the magnetic flux through a secondary coil so as to vary the induction through the coil and the voltage induced in it. The shunting should be effected smoothly, thus avoiding sudden changes in the induced voltage.

258 In TRANSFORMER VOLTAGE CONTROL, by change of ratio, it is necessary that the transition from one step to another be made without interruption of the test voltage, and by steps sufficiently small to prevent surges in the testing circuit. The necessity of this precaution is greater as the inductance or the static capacity of the apparatus in the testing circuit under test is greater.

259 When RESISTANCE COILS OR REACTORS are used for voltage control, it is desirable that the testing voltage should be secured when the controlling resistance or reactance is very nearly or entirely out of circuit in order that the disturbing effect upon the wave form which results may be negligible at the highest voltage.

F. CONDUCTIVITY.

260 COPPER. The conductivity of copper in electric wires and cables should not be less than 98% of Matthiessen's standard of conductivity, as defined in the Copper Wire Table of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

G. RISE OF TEMPERATURE.

(I) *MEASUREMENT OF TEMPERATURE.*

(*A*) METHODS.

261 There are two methods in common use for determining the rise in temperature, viz.: (1) by thermometer, and (2) by increase in resistance of an electric circuit.

262 1. By THERMOMETER. The following precautions should be observed in the use of thermometers:

263 *a*. PROTECTION. The thermometers indicating the room temperature should be protected from thermal radiation emitted by heated bodies, or from draughts of air or from temporary fluctuations of temperature. Several room thermometers should be used. In using the thermometer by applying it to a heated part, care should be taken s- to protect its bulb as to prevent radiation from it, and, at the same time, not to interfere seriously with the normal radiation from the part to which it is applied.

264 *b*. BULB. When a thermometer is applied to the free surface of a machine, it is desirable that the bulb of the thermometer should be covered by a pad of definite area. A convenient pad may be formed of cotton waste in a shallow circular box about one and a half inches in diameter, through a slot in the side in which the thermometer bulb is inserted. An unduly large pad over the thermometer tends to interfere with the natural liberation of heat from the surface to which the thermometer is applied.

265 2. By Increase in Resistance. The resistance may be measured either by Wheatstone bridge, or by drop-of potential method. A temperature coefficient of 0.42 per cent. per degree C., from and at 0° C., may be assumed for copper.

The temperature-coefficients from and at each degree cent. between 0° C. and 50° C. are given in Appendix E. The temperature rise may be determined either (1) by dividing the percentage increase of initial resistance by the temperature-coefficient for the initial temperature expressed in per cent.; or (2) by multiplying the increase in per cent. of the initial resistance by 238.1 plus the initial temperature in degrees C., and then dividing the product by 100.

266 3. Comparison of Methods. In electrical conductors, the rise of temperature should be determined by their increase of resistance where practicable. Temperature elevations measured in this way are usually in excess of temperature elevations measured by thermometers. In very low resistance circuits, thermometer measurements are frequently more reliable than measurements by the resistance method. Where a thermometer applied to a coil or winding, indicates a higher temperature elevation than that shown by resistance measurement, the thermometer indication should be accepted.

(*B*) Normal Conditions for Tests.

267 1. Duration of Tests. The temperature should be measured after a run of sufficient duration for the apparatus to reach a practically constant temperature. This is usually from 6 to 18 hours, according to the size and construction of the apparatus. It is permissible, however, to shorten the time of the test by running a lesser time on an overload in current and voltage, then reducing the load to normal, and maintaining it thus until the temperature has become constant.

268 2. Room Temperature. The rise of temperature should be referred to the standard condition of a room temperature of 25° C.

269 Temperature Correction. If the room temperature during the test differs from 25° C., correction on account of difference in resistance should be made by changing the observed rise of temperature by one-half per cent. for each degree C. Thus with a room temperature of 35° C., the observed rise of temperature has to be decreased by 5 per cent., and with a room temperature of 15° C., the observed rise of temperature has to be increased by 5 per cent. In certain cases, such as shunt-field circuits without rheostat, the current strength will be changed by a change of room temperature. The heat-production and dissipation may be thereby affected. Correction for this should be made by changing the observed rise in temperature in proportion as the $I^2 R$ loss in the resistance of the apparatus is altered owing to the difference in room temperature.

270 3. Barometric Pressure. Ventilation. A barometric pressure of 760 mm. and normal conditions of ventilation should be considered as standard, and the apparatus under test should neither be exposed to draught nor enclosed, except where expressly specified. The barometric pressure needs to be considered only when differing greatly from 760 mm.

271 Barometric Pressure Correction. When the barometric pressure differs greatly from the standard pressure of 760 mm. of mercury, as at high altitudes, a correction should be applied. In the absence of more accurate data, a correction of 1% of the observed rise in temperature for each 10 mm. deviation from the 760 m.m. standard is recommended. For example at a barometric pressure of 680 mm. the observed rise of temperature is to be reduced by $\frac{760-680}{10} = 8\%$

(II) *LIMITING TEMPERATURE RISE.*

272 General. The temperature of electrical machinery under regular service conditions, should never be allowed to remain at a point at which permanent deterioration of its insulating material takes place.

273 Limits Recommended. It is recommended that the following maximum

values of temperature elevation, referred to a standard room temperature of 25 degrees centigrade, at rated load under normal conditions of ventilation or cooling, should not be exceeded.

(*A*) Machines in General.

274 In commutating machines, rectifying machines, pulsating-current generators, synchronous machines, synchronous commutating machines and unipolar machines, the temperature rise in the parts specified should not exceed the following:

275 Field and armature, 50° C.

276 Commutator and brushes, by thermometer, 55° C.

277 Collector rings, 65° C.

278 Bearings and other parts of machine, by thermometer, 40° C.

279 (*B*) Rotary Induction Apparatus. The temperature rise should not exceed the following:

280 Electric circuits, 50° C., by resistance.

281 Bearings and other parts of the machine 40° C., by thermometer.

282 In squirrel-cage or short-circuited armatures, 55° C., by thermometer. may be allowed.

(*C*) Stationary Induction Apparatus.

283 *a*. Transformers for Continuous Service. The temperature rise should not exceed 50 degrees centigrade in electric circuits, by resistance; and in other parts, by thermometer.

284 *b*. Transformers for Intermittent Service. In the case of transformers intended for intermittent service, or not operating continuously at rated load, but continuously in circuit, as in the ordinary case of lighting transformers, the temperature elevation above the surrounding air-temperature should not exceed 50° C., by resistance in electric circuits and by thermometer in other parts, after the period corresponding to the term of rated load. In this instance, the test load should not be applied until the transformer has been in circuit for a sufficient time to attain the temperature elevation due to core loss. With transformers for commercial lighting, the duration of the rated-load test may be taken as three hours, unless otherwise specified.

285 *c*. Reactors, induction- and magneto-regulators—electric circuits by resistance and other parts by thermometer, 50° C.

286 *a*. Large Apparatus. Large generators, motors, transformers, or other apparatus in which reliability and reserve overload capacity are important, are frequently specified not to rise in temperature more than 40 degrees centigrade under rated load and 55 degrees centigrade at rated overload. It is, however, ordinarily undesirable to specify lower temperature elevations than 40 degrees centigrade at rated load, measured as above.

(*D*) Rheostats.

287 In Rheostats, Heaters and other electrothermal apparatus, no combustible or inflammable part or material, or portion liable to come in contact with such material, should rise more than 50° C. above the surrounding air under the service conditions for which it is designed.

288 *a*. Parts of Rheostats. Parts of rheostats and similar apparatus rising in temperature, under the specified service conditions, more than 50° C., should not contain any combustible material, and should be arranged or installed in such a manner that neither they, nor the hot air issuing from them, can come in contact with combustible material.

(*E*) Limits Recommended in Special Cases.

289 *a*. Heat Resisting Insulation. With apparatus in which the insulating materials have special heat-resisting qualities, a higher temperature elevation is permissible.

290 *b*. High Air Temperature. In apparatus intended for service in places of abnormally high temperature, a lower temperature elevation should be specified.

291 *c*. Apparatus Subject to Overload. In apparatus which by the nature of its service may be exposed to overload, or is to be used in very high voltage circuits, a smaller rise of temperature is desirable than in apparatus not liable to overloads or in low-voltage apparatus. In apparatus built for conditions of limited space, as railway motors, a higher rise of temperature must be allowed.

292 *d.* APPARATUS FOR INTERMITTENT SERVICE. In the case of apparatus intended for intermittent service, except railway motors, the temperature elevation which is attained at the end of the period corresponding to the term of rated load, should not exceed the values specified for machines in general. In such apparatus the temperature elevation, including railway motors, should be measured after operation, under as nearly as possible the conditions of service for which the apparatus is intended, and the conditions of the test should be specified.

H. OVERLOAD CAPACITIES.

293 PERFORMANCE WITH OVERLOAD. All apparatus should be able to carry the overload hereinafter specified without serious injury by heating, sparking, mechanical weakness, etc., and with an additional temperature rise not exceeding 15° C., above those specified for rated loads. the overload being applied after the apparatus has acquired the temperature corresponding to rated load continuous operation. Rheostats to which no temperature rise limits are attached are naturally exempt from this additional temperature rise of 15° C. under overload specified in these rules.

294 NORMAL CONDITIONS. Overload guarantees should refer to normal conditions of operation regarding speed, frequency, voltage, etc., and to non-inductive conditions in alternating apparatus, except where a phase displacement is inherent in the apparatus.

295 OVERLOAD CAPACITIES RECOMMENDED. The following overload capacities are recommended:

296 *a.* GENERATORS. Direct-current generators and alternating-current generators, 25 per cent. for two hours.

297 *b.* MOTORS. Direct-current motors, induction motors and synchronous motors, not including railway and other motors intended for intermittent service, 25 per cent. for two hours, and 50 per cent. for one minute.

298 *c.* CONVERTERS. Synchronous converters, 25 per cent. for two hours, 50 per cent. for one-half hour.

299 *d.* TRANSFORMERS AND RECTIFIERS. Constant-potential transformers and rectifiers, 25 per cent. for two hours; except in transformers connected to apparatus for which a different overload is guaranteed, in which case the same guarantees shall apply for the transformers as for the apparatus connected thereto.

300 *e.* EXCITERS. Exciters of alternators and other synchronous machines, 10 per cent. more overload than is required for the excitation of the synchronous machine at its guaranteed overload, and for the same period of time. All exciters of alternating-current, single-phase or polyphase generators should be able to give at its rated speed, sufficient voltage and current to excite the alternator, at the rated speed, to the full-load terminal voltage, at the rated output in kilovolt-amperes and with 50 per cent. power factor.

301 *f.* A CONTINUOUS-SERVICE RHEOSTAT, such as an armature- or field-regulating rheostat, should be capable of carrying without injury for two hours, a current 25 per cent. greater than that at which it is rated. It should also be capable of carrying for one minute a current 50 per cent. greater than its rated load current, without injury. This excess of capacity is intended for testing purposes only, and this margin of capacity should not be relied upon in the selection of the rheostat.

302 *g.* An INTERMITTENT SERVICE OR MOTOR-STARTING RHEOSTAT is used for starting a motor from rest and accelerating it to rated speed. Under ordinary conditions of service, and unless expressly stated otherwise, a motor is assumed to start in fifteen seconds and with 150% of rated current strength. A motor-starter should be capable of starting the motor under these conditions once every four minutes for one hour.

303 (*a*) This TEST may be carried out either by starting the motor at four-minute intervals, or by placing the starter at normal temperature across the maximum voltage for which it is marked, and moving the lever uniformly and gradually from the first to the last position during a period of fifteen seconds, the current being maintained substantially constant at said 50% excess by introducing resistance in series or by other suitable means.

804 (*b*) Other Rheostats for Intermittent-Service are employed under such special and varied conditions, that no general rules are applicable to them.

III. VOLTAGES AND FREQUENCIES.

A. VOLTAGES.

805 Direct-Current Generators. In direct-current, low-voltage generators, the following average terminal voltages are in general use and are recommended:

125 volts. 250 volts. 550 to 600 volts.

806 Low-Voltage Circuits. In direct-current and alternating-current low-voltage circuits, the following average terminal voltages are in general use and are recommended:

110 volts. 220 volts.

807 Primary Distribution Circuits. In alternating-current, constant-potential, primary-distribution circuits, an average voltage of 2,200 volts, with step-down transformer ratios 1/10 and 1/20, is in general use, and is recommended.

808 Transmission Circuits. In alternating-current constant-potential transmission circuits, the following average voltages are recommended.

6,600 11,000 22,000 33,000 44,000 66,000 88,000

809 Transformer Ratio. It is recommended that the standard transformer ratios should be such as to transform between the standard voltages above named. The ratio will, therefore, usually be an exact multiple of 5 or 10, *e. g.*, 2,200 to 11,000; 2,200 to 44,000.

810 Range in Voltage. In alternating-current generators, or generating systems, a range of terminal voltage should be provided from rated voltage at no load to 10 per cent. in excess thereof, to cover drop in transmission. If a greater range than ten per cent. is specified, the generator should be considered as special.

B. FREQUENCIES.

811 In Alternating-Current Circuits, the following frequencies are standard:

25~ 60~

812 These frequencies are already in extensive use and it is deemed advisable to adhere to them as closely as possible.

IV. GENERAL RECOMMENDATIONS.

813 Name Plates. All electrical apparatus should be provided with a name plate giving the manufacturer's name, the voltage and the current in amperes for which it is designed. Where practicable, the kilowatt capacity, character of current, speed, frequency, type, designation and serial number should be added.

814 Diagrams of Connections. All electrical apparatus when leaving the factory should be accompanied by a diagram showing the electrical connections and the relation of the different parts in sufficient detail to give the necessary information for proper installation.

815 Rheostat Data. Every rheostat should be clearly and permanently marked with the voltage and amperes, or range of amperes, for which it is designed.

816 Colored Indicating Lights. When using colored indicating lights on switch-boards, red should denote danger such as "switch closed," or "circuit alive"; green should denote safety, such as "switch open," or "circuit dead."

317 When white lights are used a light turned on should denote danger, such as "switch closed" or "circuit alive"; while the light out should denote safety, such as "switch open," or "circuit dead." Low-efficiency lamps should be used.

318 The use of colored lights is recommended, as safer than white lights.

319 GROUNDING METAL WORK. It is desirable that all metal work near high potential circuits be grounded.

320 CIRCUIT OPENING DEVICES. The following definitions are recommended.

321 *a.* A CIRCUIT-BREAKER is an apparatus for breaking a circuit at the highest current which it may be called upon to carry.

322 *b.* A DISCONNECTING SWITCH is an apparatus designed to open a circuit only when carrying little or no current.

323 *c.* An AUTOMATIC CIRCUIT-BREAKER is an apparatus for breaking a circuit automatically under an excessive strength of current. It should be capable of breaking the circuit repeatedly at rated voltage and at the maximum current which it may be called upon to carry.

V. APPENDICES AND TABULAR DATA.

APPENDIX A. NOTATION.

The following notation is recommended:

324 E, e, voltage, e.m.f., potential difference
I, i, current
P, power
Φ, magnetic flux
$\mathfrak{B}$, B, magnetic density
R, r, resistance
x, reactance
Z, z, impedance
L, l, inductance
C, c, capacity
Y, y, admittance
b, susceptance
G, g, conductance
Vector quantities when used should be denoted by capital **italics.**

APPENDIX B.—RAILWAY MOTORS.

(I) *RATING.*

325 INTRODUCTORY NOTE ON RATING. Railway motors usually operate in a service in which both the speed and the torque developed by the motor are varying almost continually. The average requirements, however, during successive hours in a given class of service are fairly uniform. On account of the wide variation of the instantaneous loads, it is impracticable to assign any simple and definite rating to a motor which will indicate accurately the absolute capacity of a given motor or the relative capacity of different motors under service conditions. It is also impracticable to select a motor for a particular service without much fuller data with regard both to the motor and to the service than is required, for example, in the case of stationary motors which run at constant speeds.

326 SCOPE OF NOMINAL RATING. It is common usage to give railway motors a nominal rating in horse power on the basis of a one-hour test. As above explained, a simple rating of this kind is not a proper measure of service capacity. This nominal rating, however, indicates approximately the maximum output which the motor should ordinarily be called upon to develop during acceleration. Methods of determining the continuous capacity of a railway motor for service requirements are given under a subsequent heading.

327 The NOMINAL RATING of a railway motor is the horse-power output at the car-axle, that is, including gear and other transmission losses, which gives a rise of temperature above the surrounding air (referred to a room

temperature of 25 degrees cent.) not exceeding 90 degrees cent. at the commutator and 75 degrees Cent. at any other part after one hour's continuous run at its rated voltage (and frequency, in the case of an alternating-current motor) on a stand, with the motor-covers removed, and with natural ventilation. The rise in temperature is to be determined by thermometer, but the resistance of no electrical circuit in the motor shall increase more than 40% during the test.

(II) *SELECTION OF MOTOR FOR SPECIFIED SERVICE.*

328 General Requirements. The suitability of a railway motor for a specified service depends upon the following considerations:

329 *a.* Mechanical ability to develop the requisite torque and speeds as given by its speed-torque curve.

330 *b.* Ability to commutate successfully the current demanded.

331 *c.* Ability to operate in service without occasioning a temperature rise in any part which will endanger the life of the insulation.

332 Operating Conditions, Typical Run. The operating conditions which are important in the selection of a motor include the weight of load, the schedule speed, the distance between stops, the duration of stops, the rate of acceleration and of braking retardation, the grades and the curves. With these data at hand, the outputs which are required of the motor may be determined, provided the service requirements are within the limits of the speed-torque curve of the motor. These outputs may be expressed in the form of curves giving the instantaneous values of current and of voltage which must be applied to the motor. Such curves may be laid out for the entire line, but they are usually constructed only for a certain average or typical run, which is fairly representative of the conditions of service. To determine whether the motor has sufficient capacity to perform the service safely, further tests or investigations must be made.

333 Capacity Test of Railway Motor in Service. The capacity of a railway motor to deliver the necessary output may be determined by measurement of its temperature after it has reached a maximum in service. If a running test cannot be made under the actual conditions of service, an equivalent test may be made in a typical run back and forth, under such conditions of schedule speed, length of run, rate of acceleration, etc., that the test cycle of motor losses and conditions of ventilation are essentially the same as would be obtained in the specified service.

334 Methods of Comparing Motor Capacity with Service Requirements. Where it is not convenient to test motors under actual service conditions or in an equivalent typical run, recourse may be had to one of the two following methods of determining temperature rise now in general use:

335 1. Method by Losses and Thermal Capacity Curves. The heat developed in a railway motor is carried partly by conduction through the several parts and partly by convection through the air to the motor-frame whence it is distributed to the outside air. As the temperature of the several parts is thus dependent not only upon their own internal losses but also upon the temperature of neighboring parts, it becomes necessary to determine accurately the actual value and distribution of losses in a railway motor for a given service and reproduce them in an equivalent test-run The results of a series of typical runs expressed in the form of thermal capacity curves will give the relation between degrees rise per watt loss in the armature and in the field for all ratios of losses between them met with in the commercial application of a given motor.

336 This method consists, therefore, in calculating the several internal motor losses in a specified service and determining the temperature rise with these losses from thermal capacity curves giving the degrees rise per watt loss as obtained in experimental track tests made under the same conditions of ventilation.

337 The following motor losses cause its heating and should be carefully determined for a given service: $I^2 R$ in the field; $I^2 R$ in the armature; $I^2 R$ in the brush contacts, core loss and brush friction.

338 The loss in the bearings (in the case of geared motors) also adds somewhat to the motor-heating, but owing to the variable nature of such losses they are generally neglected in making calculations.

339 2. Method by Continuous Capacity of Motor. The essential losses in the motor, as found in the typical run, are in most cases those in the motor windings and in the core. The mean service conditions may be expressed in terms of the current which would produce the same losses in the motor windings and the voltage which, with that current, would produce the same core losses as the average in service. The continuous capacity of the motor is given in terms of the amperes which it will carry when run on a testing stand—with covers on or off, as specified—at different voltages, say, 40, 60, 80 and 100 per cent. of the rated voltage—with a temperature rise not exceeding 90 degrees at the commutator and 75 degrees at any other part, provided the resistance of no electric circuit in the motor increases more than 40 per cent. A comparison of the equivalent service conditions with the continuous capacity of the motor will determine whether the service requirements are within the safe capacity of the motor.

340 This method affords a ready means of determining whether a specified service is within the capacity of a given motor and it is also a convenient approximate method for comparing the service capacities of different motors.

APPENDIX C. PHOTOMETRY AND LAMPS.

341 Candle-Power. The luminous intensity of sources of light is expressed in candle-power. The unit of candle-power should be derived from the standards maintained by the National Bureau of Standards at Washington, D. C., which standard unit of candle-power equals 100/88 of the Hefner unit under Reichsanstalt standard conditions for the Hefner. In practical measurements seasoned and carefully standardized incandescent lamps are more reliable and accurate than the primary standard.

342 Candle-Lumen. The total flux of light from a source is equal to its mean spherical intensity multiplied by 4π. The unit of flux is called the candle-lumen. A candle lumen is the $\frac{1}{4\pi}$th part of the total flux of light emitted by a source having a mean spherical intensity of one candle-power.

343 Candle-Meter. The unit of illumination is the candle-meter. This is the normal illumination produced by one unit of candle-power at a distance of one metre.

344 *a.* Candle-Foot. Illumination is occasionally expressed in candle-feet. A candle-foot is the normal illumination produced by one unit of candle-power at a distance of one foot.

345 1 candle-foot = 10.764 candle-metres.

The use of the candle-metre unit is preferable and is recommended.

346 The Efficiency of Electric Lamps is properly stated in terms of mean spherical candle-power per watt at lamp terminals. This use of the term efficiency is to be considered as special, and not to be confused with the generally accepted definition of efficiency in Sec. 85.

347 *a.* Efficiency, Auxiliary Devices. In illuminants requiring auxiliary power-consuming devices outside of the luminous body, such as steadying resistances in constant potential arc lamps, a distinction should be made between the net efficiency of the luminous source and the gross efficiency of the lamp. This distinction should always be stated. The gross efficiency should include the power consumed in the auxiliary resistance, etc. The net efficiency should, however, include the power consumed in the controlling mechanism of the lamp itself. Comparison between such sources of light should be made on the basis of gross efficiency, since the power consumed in the auxiliary device is essential to the operation.

348 *b.* A Standard Circuit Voltage of 110 volts, or a multiple thereof may be assumed, except where expressly stated otherwise.

349 Watts per Candle. The specific consumption of an electric lamp is its watt consumption per mean spherical candle-power. "Watts per candle" is the term used commercially in connection with incandescent lamps, and denotes, watts per mean horizontal candle-power.

350 Photometric Tests in which the results are stated in candle-power should always be made at such a distance from the source of light that

the latter may be regarded as practically a point. Where tests are made at shorter distances, as for example in the measurement of lamps with reflectors, the results should always be given as " apparent candle-power " at the distance employed, which distance should always be specifically stated.

351 BASIS FOR COMPARISON. Either the total flux of light in candle-lumens, or the mean spherical candle-power, should always be used as the basis for comparing various luminous sources with each other, unless there is a clear understanding or statement to the contrary.

352 INCANDESCENT LAMPS, RATING. It is customary to rate incandescent lamps on the basis of their mean horizontal candle-power; but in comparing incandescent lamps in which the relative distribution of luminous intensity differs, the comparison should be based on their total flux of light measured in lumens, or on their mean spherical candle-power.

353 The SPHERICAL REDUCTION-FACTOR of a lamp

$$= \frac{\text{mean spherical candle-power}}{\text{mean horizontal candle-power}}$$

354 The TOTAL FLUX of light in candle-lumens emitted by a lamp $= 4\pi \times$ mean horizontal candle-power $\times$ spherical reduction-factor.

355 The SPHERICAL REDUCTION-FACTOR should only be used when properly determined for the particular type and characteristics of each lamp. The spherical reduction-factor permits of substantially accurate comparisons being made between the mean spherical candle-powers of different types of incandescent lamps, and may be used in the absence of proper facilities for direct measurement of mean spherical intensity.

356 "READING DISTANCE." Where standard photometric measurements are impracticable, approximate measurements of illuminants such as street lamps may be made by comparing their "reading distances;" *i.e.*, by determining alternately the distances at which an ordinary size of reading print can just be read, by the same person or persons, when all other light is screened. The angle below the horizontal at which the measurement is made should be specified when it exceeds 15°.

357 In COMPARING DIFFERENT LUMINOUS SOURCES not only should their candle-power be compared, but also their relative form, intrinsic brilliancy, distribution of illumination and character of light.

APPENDIX D. SPARKING DISTANCES.

358 Table of Sparking Distances in Air between Opposed Sharp Needle-Points, for Various Effective Sinusoidal Voltages, in inches and in centimetres. The table applies to the conditions specified in Secs. 240-246.

359

Kilovolts Sq Root of Mean Square	Distance. Inches	Cms.	Kilovolts Sq. Root of Mean Square	Distance. Inches	Cms.
5	0.225	0.57	140	13.95	35.4
10	0.47	1.19	150	15.0	38.1
15	0.725	1.84	160	16.05	40.7
20	1.0	2.54	170	17.10	43.4
25	1.3	3.3	180	18.15	46.1
30	1.625	4.1	190	19.20	48.8
35	2.0	5.1	200	20.25	51.4
40	2.45	6.2	210	21.30	54.1
45	2.95	7.5	220	22.35	56.8
50	3.55	9.0	230	23.40	59.4
60	4.65	11.8	240	24.45	62.1
70	5.85	14.9	250	25.50	64.7
80	7.1	18.0	260	26.50	67.3
90	8.35	21.2	270	27.50	69.8
100	9.6	24.4	280	28.50	72.4
110	10.75	27.3	290	29.50	74.9
120	11.85	30.1	300	30.50	77.4
130	12.90	32.8			

APPENDIX E. TEMPERATURE COEFFICIENTS.

360 Table of Temperature Coefficients of Resistivity in Copper at Different Initial Temperatures Centigrade.

Initial temperature cent. i	Temp. coefficient. in percent. per degree cent.	Initial temperature cent. i	Temp. coefficient. in percent. per degree cent.
0	0.4200	26	0.3786
1	0.4182	27	0.3772
2	0.4165	28	0.3758
3	0.4148	29	0.3744
4	0.4131	30	0.3730
5	0.4114	31	0.3716
6	0.4097	32	0.3702
7	0.4080	33	0.3689
8	0.4063	34	0.3675
9	0.4047	35	0.3662
10	0.4031	36	0.3648
11	0.4015	37	0.3635
12	0.3999	38	0.3622
13	0.3983	39	0.3609
14	0.3967	40	0.3596
15	0.3951	41	0.3583
16	0.3936	42	0.3570
17	0.3920	43	0.3557
18	0.3905	44	0.3545
19	0.3890	45	0.3532
20	0.3875	46	0.3520
21	0.3860	47	0.3508
22	0.3845	48	0.3495
23	0.3830	49	0.3483
24	0.3815	50	0.3471
25	0.3801		

The fundamental relation between the increase of resistance in copper and the rise of temperature may be taken as

$$R_t = R_0\,(1 + 0.0042\,t)$$

where R_0 is the resistance of the copper conductor at 0° C. and R_t is the corresponding resistance at t° C. This is equivalent to taking a temperature coefficient of 0.42% per deg. C. temperature rise above 0° C. For initial temperatures other than 0° C., a similar formula may be used substituting the coefficients in the above table corresponding to the actual initial temperature. The formula thus becomes at 25° C.

$$R_{i+r} = R_i\,(1 + \frac{0.3801\,r}{100})$$

where R_i is the initial resistance at 25° C. R_{i+r} the final resistance and r the temperature rise above 25° C.

In order to find the temperature rise in degrees cent. from the initial resistance R_i at the initial temperature $i°$ C. and the final resistance R_{i+r} we may use the formula

$$r = (238.1 + i)\left(\frac{R_{i+r}}{R_i} - 1\right) \quad \text{degrees C.}$$

See Sec. 265.

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